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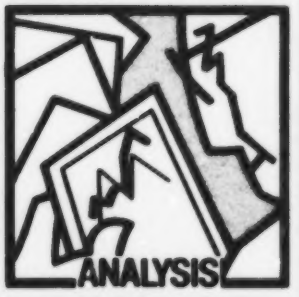

ONCOLOGY OVERVIEW

SELECTED ABSTRACTS

ON COMPLETED

CARCINOGENIC CONTAMINANTS OF WATER SUPPLIES

February 26, 1980

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • National Institutes of Health •
National Cancer Institute

A SERVICE OF THE
INTERNATIONAL CANCER RESEARCH DATA BANK (ICRDB)

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Selected Abstracts

On

CARCINOGENIC CONTAMINANTS OF WATER SUPPLIES

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Consulting Reviewer

A Service of the International Cancer Research Data Bank (ICRDB) Program of the National Cancer Institute

INTRODUCTION

This ONCOLOGY OVERVIEW on the carcinogenic contaminants of water supplies includes abstracts selected from the CANCERLINE data base, referencing articles published mainly during 1975-79. In some cases, selected information from the 1960's is included for historical value. The strategy used to retrieve these abstracts is available on request from the CIDAC office and can be entered at any MEDLARS/MEDLINE terminal system in order to obtain continuing updates in this area.

The scope of this OVERVIEW includes all aspects of the potential carcinogenicity of contaminants of water supplies, including the occurrence, formation and analysis of water contaminants, epidemiological and clinical associations of water contaminants with human cancers, carcinogenicity and mutagenicity studies in experimental systems and aquatic organisms, and regulations and public health issues concerning carcinogenic contaminants of water supplies. Studies on radionuclide contamination of water are also included.

This OVERVIEW was prepared by Lorne Houten, Ph.D. and Anita K. Bahn, Ph.D. (Editors) of the Department of Research Medicine, University of Pennsylvania, and Harriet Glaser Hill, M.S. of the CIDAC for Carcinogenesis Information, The Franklin Research Center.

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EDITORIAL COMMENTARY

In 1974, it was reported that pollution in the Mississippi River was the cause of some of the excess cancer in New Orleans, Louisiana. This report was followed by a series of correlative (ecologic) studies which established a statistical relationship between increased incidence of cancers of the urinary and gastrointestinal tract and for total cancer incidence, and the use of water from the Mississippi River as opposed to the use of other water sources (1)(2). A further study established a statistical correlation between higher cancer rates in parishes with surface water sources and lower rates in parishes using ground water (3).

A similar study in Ohio showed a significant correlation in rates for all cancer deaths as well as for cancer of the stomach and bladder with the use of surface as opposed to ground water; however, no correlation was apparent with the use of water from the Ohio River (4)(5). Elevated incidence of brain tumors was noted in Kentucky counties located on major tributaries of the Kentucky and Licking Rivers (6).

In many of these studies, the authors were careful in their analysis to adjust statistically for as many confounding factors as possible. In addition, there is logical plausibility to the hypothesis that surface water, which is more likely to be contaminated by environmental pollutants, might be associated with increased cancer risks. Nonetheless, care must be taken in accepting the results of correlational studies. Conclusions from correlational studies may be spurious because of the "ecological fallacy", i.e. the observed correlation may be only an artifactual association of the factor in question with the "real" factor involved. As a result, correlational studies should be viewed merely as suggestive until substantiation from case-control studies is obtained (7)(8)(9).

Many factors have been identified as potential carcinogens in the water supply. Arsenic is a suspected carcinogen, particularly in its trivalent form. Arsenic appears to cause cutaneous lesions characterized by hyperpigmentation and keratosis; blackfoot disease, a vascular disorder which results in gangrene of the extremities; and possibly cancer of the skin. These conditions are correlated with the use of water from wells with high arsenic content in Taiwan (10)(11). There are dose-response relationships between the incidence of these conditions and arsenic intake (12) and between body arsenic dose and age (13). Decreased prevalence of precancerous skin conditions was found after filtration of water for arsenic content in Chile (14). However, no clinical abnormalities were found in a survey of Alaskan well-water drinkers exposed to high arsenic levels (15).

Some reports have attempted to correlate the presence of fluorides in the drinking water with elevated cancer rates (16). Several other studies based on the same and comparable data bases could not ascribe any trends in cancer mortality to the consumption of fluoridated water (17)(18)(19)(20).

Several studies of areas in South America with elevated rates of cancer of the stomach have found correlations with levels of nitrates in the water (21)(22)(23). The nitrates in the water may serve as substrates for the endogenous formation of carcinogenic N-nitroso compounds, particularly in the achlorhydric stomach or in the stomach disturbed by intestinal metaplasias (24)(25). In addition, several N-nitroso compounds which are occasionally found in well-water, wastewater from chemical plants, and in drinking water have been determined to be carcinogenic in animals (26)(27)(28)(29).

Asbestos can enter the drinking water both from natural (e.g. volcanic rock) or from man-made (water pipe and dumping) routes (30)(31). Asbestos fibers can apparently distribute themselves from the GI tract to other parts of the body. Nevertheless, neither asbestos from pipes nor from contamination of water through dumping have shown a significant correlation to cancer rates (32)(33)(34).

Several trace metals including lead, chromium, copper, zinc, nickel and cadmium are spread via the water supply. One study indicated several correlations between trace metal levels and several forms of cancer, e.g., cadmium with oral and pharyngeal cancer, esophageal cancer, breast cancer and leukemias (35). Other studies have confirmed some of these associations, failed to confirm others and identified new associations (36). Definitive conclusions will require case control studies.

A wide variety of hydrocarbons including benzo(a)pyrene and other polycyclic aromatics, vinyl chloride, polychlorinated biphenyls, polybrominated biphenyls, tetrachloroethylene, benzene, carbon tetrachloride, chloroform and other trihalomethanes are found as contaminants in water. Halomethanes may occur as reaction products between naturally occurring hydrocarbons and chlorine applied during the chlorination process (37)(38)(39). Positive statistical correlations were found between elevated halomethane levels in water supplies and excess rates of cancer of the bladder, brain, lung and colon in both sexes and non-Hodgkin's lymphoma and cancer of the kidneys in males. A negitive correlation was found for stomach cancer in females (40)(41).

Many radionuclides, including Pt239, Am241, Co60, Ra226, Sr90, Cs137, Rn222, Po210, and H3 are found in water. Correlations between radionuclide levels in water and cancer mortality rates are not well documented.

One approach to determining the carcinogenicity of water components is to use the "natural laboratory" situation by observing aquatic organisms. Gonadal tumors and papillomas were found in carp and goldfish living in polluted water. It was suggested that chemical pollutants in the water may interact with genetic and viral factors to produce these tumors (42). Lymphosarcomas are found in pike of the genus Esox in polluted water of the Fox River. A direct relationship between chemical pollution of waterways and the frequency of fish tumors has been indicated (43)(44). Another study noted a seasonal variation in the tumor incidence in English sole (45).

N-nitroso compounds were noted to increase the numbers of tumors in bivalve molluscs exposed in laboratory tanks (46). Tumor incidence was dose-dependent. The authors suggest that molluscs can be used to determine the carcinogenicity of nitroso compounds and to indicate water pollutants. Polluted water was seen to induce the aryl hydrocarbon hydroxylase system in salamanders (47). It was suggested that bottom dwelling flatfish, which tend to be exposed to higher levels of pollutants, be used as an indicator species for examining the chemical carcinogens in subtidal and intertidal waters (48).

Animal studies of the carcinogenic effect of chlorination have yielded mixed results (49)(50). However, mice fed hyperchlorinated water (25-30 ppm) developed profound alteration in the number of peritoneal exudate macrophages and in tumoricidal function. The author suggests that hyperchlorination of drinking water may compromise the host resistance against neoplasms (51). Injection or subcutaneous administration of chloroform or ethanol extracts of raw water from a river downstream from chemical and rubber plants produced tumors in mice. Treatment with similar extracts of finished water did not produce tumors (52). Other studies have shown both chloroform and dieldrin, widespread water contaminants, to be carcinogenic in rats and mice (53)(54).

Mutagenicity studies have indicated that many water pollutants are mutagenic. In one study, nineteen compounds found in water were positive in the Ames mutagenicity test. Both the raw and finished water from fourteen cities were Ames tested (55). Some raw and most of the finished waters tested were Ames positive. In one study, however, water from polluted Chesapeake Bay was Ames negative (56). Very heavy ozonation has produced Ames positive water (57). In addition to industrial and other man-made pollutants, many naturally occurring agents such as fungi and alkaloids can introduce mutagens into the water (58).

Many methods are suggested for analyzing carcinogenic components in water. These methods include: gas chromatography-mass spectrophotometry (59), reverse osmosis (60), thermal energy analyzer liquid chromatography (61), resin extraction (62), electron capture gas chromatography (63), and atomic absorption spectroscopy (64).

Many scientific questions relating to the understanding of carcinogenesis remain unanswered. The question of low dose extrapolation and the existence of thresholds are the subject of unresolved debate. Criteria are needed to evaluate the predictive value of animal and mutagenesis data. Further research is needed to understand possible synergism or inhibition of mixed agents. The carcinogenicity of many agents is difficult to evaluate since only their metabolic products are active.

Many suggestions were made for improved laws to curb pollutants in the drinking water, such as asbestos (65), nitrates (66), radionuclides (67) and carbon tetrachloride (68).

It has been suggested that 80% of all cancers are related to the environment (69). Better scientific methods are needed to evaluate the large number of agents which may be involved in environmental

carcinogenesis. In addition, further epidemiologic studies, using appropriate methodology and taking into account the methodologic limitations related to latency and migration, are needed to accurately determine which risk factors are important and to avoid ecological fallacies. Congenital malformation studies which obviate some of the above difficulties may be useful.

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I. OCCURRENCE AND FORMATION AND ANALYSIS OF CARCINOGENIC CONTAMINANTS OF WATER SUPPLIES

A. Occurrence and Formation of Potential Carcinogenic Contaminants of Water Supplies

1. PRELIMINARY INVESTIGATIONS INTO THE PRESENCE OF HALOFORMS IN MASSACHUSETTS DRINKING WATER SUPPLIES.

Sylvia AE, Miller JD, Baxter WS
Lawrence Experiment Station, Massachusetts Dept. Environmental Quality Engineering, Lawrence, MA
N Engl Water Works Assoc; 92(1):30-39 1978

Preliminary investigations into the presence of haloforms in Massachusetts drinking water supplies are reported. An Environmental Protection Agency (EPA) study of drinking water in 80 cities, including 4 in New England (2 in Massachusetts and 1 each in Connecticut and Rhode Island), showed that 3-4 New England waters contained concentrations of chloroform (greater than 91 microg/liter) and bromodichloromethane (greater than 9.0 microg/liter) which were considerably higher than the median concentrations (21 microg liter for chloroform and 6 microg liter for bromodichloromethane) as determined in the EPA survey. Another study of the drinking water supplies of cities and towns in Massachusetts using chlorination for disinfection showed that the concentration of chloroform in drinking water varied widely from place to place. The role of temperature in the formation of haloforms could not be determined, but it was apparent that reaction or contact time plays a major role in the ultimate haloform production. This was evidenced by a marked increase in concentrations found in the distribution system samples as opposed to those values obtained at the point of chlorination. The control of halomethane production is discussed. (no Refs)

2. FORMATION OF TRIHALOMETHANES BY CHLORINATION OF SURFACE WATER.

Bunn WW, Haas BB, Deane ER, Kleopfer RD
U.S. Environmental Protection Agency, Region VII, Kansas City, KS 66115
Environ Lett; 10(3):205-213 1975

The occurrence of the previously undetected trihalogenated methane, dichloroiodomethane, in tap water from the Meramec and the Missouri Rivers is reported. A gas chromatographic mass spectrometric analysis of resin extracts was performed. Experimental evidence indicates that all 10 possible trihalogenated methanes (Cl, Br, and I, but not F) can be formed by chlorination of surface water. The addition of KF or KCl to subsequently chlorinated Missouri River water had little effect on the production of trihalogenated methanes. On the other hand, KBr or KI caused substantial reduction in chloroform concentrations with the formation of bromodichloromethane, dibromochloromethane, and bromoform or dichloroiodomethane, chlorodiiodomethane, and iodoform, respectively. Oxidation of bromide and iodide to hypobromite and hypoiodite plus a subsequent "haloform" type reaction is a possible explanation for the formation of these compounds.

3. AGRICULTURAL RUNOFF AS A SOURCE OF HALOMETHANES IN DRINKING WATER.

Morris RL, Johnson LG
State Hygienic Lab., Univ. Iowa Iowa, City, IA
Am Water Works Assoc J; 68(9):492-494 1976

Because many of the organics that could be halogenated in modern water plant disinfection processes probably exist in the run-off from agricultural land during rainy and snow-melt periods, the concentrations of several of the halogenated methanes in the surface water supplies in a modern agricultural environment were evaluated. The water was taken from selected sites in Iowa covering three internal streams and the Mississippi, with one sampling point on the Missouri river. The studies did not reveal halogenated compounds in the river waters themselves. The compounds only appeared after chlorination during the water purification process. Clarification before chlorination produced much lower chloroform levels in finished water than chlorination without previous reduction of suspended solids to low levels. Lime softening appeared to intensify the halogenation reactions. Agricultural land run-off was a major source of the organic compounds that were being chlorinated in water plants to produce halogenated methane in concentrations of current concern. The duration of the levels coincided with the duration of siltation or flow elevation episodes. (1 Refs)

4. FORMATION AND OCCURRENCE OF HALOFORMS IN DRINKING WATER IN THE FEDERAL REPUBLIC OF GERMANY.

Sonneborn M, Bohn B
Inst. Water, Soil, Air Hygiene, Federal Health Office, Berlin, W. Germany
Water Chlorination; 2:537-542 1978

Published data on the occurrence of haloforms in the drinking water in Germany are reviewed and compared to data from the United States. The higher concentrations found in the United States are probably due to higher doses of chlorine being used for disinfecting purposes. (14 Refs)

5. OCCURRENCE AND SIGNIFICANCE OF TRIHALOGENATED METHANE DERIVATIVES IN WATER.

Scholler F, Pivoda B
Umweltschutzanstalt, Sudstadt-Zentrum 4, 2344 Maria Enzersdorf, Austria
Gas Wasser Waerme; 33(3):76-79 1979

Studies on trihalogenated methane derivatives (TMD) occurring in water naturally or as a result of chlorination are reviewed. Chloroform was found to have teratogenic and carcinogenic effects. A correlation was found between the TMD level in drinking water and the incidence of cancer of the urinary bladder. (12 Refs)

6. CARCINOGENIC SUBSTANCES IN WATER.

Bartacek J
Katedra technologie vody a prostredi, VSCHT, Prague, Czechoslovakia
Vys SK Chem Technol Praze; 22:5-49 1978

Studies of the occurrence, elimination, and determination of carcinogens in various types of water are reviewed, with special regard to polycyclic aromatic hydrocarbons (PAH). The major PAH's found in water include benzo(a)pyrene,

benzo(e)pyrene, anthracene, benz(a)anthracene, 9,10-dimethylbenz(a)anthracene, dibenz(a,h)anthracene, phenanthrene, chrysene, pyrene, fluoranthene, perylene, and 3-methylcholanthrene. Benzo(a)pyrene concentrations of 2-1,000 mg m3 were found in effluents from coking and petrochemical plants. The PAH content in drinking water can be reduced by ozonation, chlorination, and UV irradiation. (321 Refs)

7. REVIEW PAPER: POLYNUCLEAR AROMATIC HYDROCARBONS IN RAW, POTABLE AND WASTE WATERS.

Harrison RM, Perry R, Wellings RA
Public Health Engineering, Imperial Coll., London S.W. 7, England
Water Res; 9(4):331-346 1975

Certain polynuclear aromatic hydrocarbons (PAH) that may be found in water can be potent carcinogens under given conditions. Probable sources of PAH compounds in the aqueous environment and the effects of water and waste water treatment processes on PAH levels are reviewed. Dried soil samples, vegetables groundwater samples, and marine organisms have all been found to have measurable PAH levels. Treated river water has been reported to contain from 0.025 to 0.234 ug l total PAH, with the carcinogenic compounds comprising 0.007 to 0.054 ug l. Untreated river water may contain a 10-times higher level of PAH than treated or groundwater. Since PAH are formed in high-temperature pyrolysis systems, effluents from industrial plants where catalytic cracking and reforming of crude oil take place may contribute PAH to rivers and sewage systems. Microorganisms in sewage, seawater, and soil degrade certain PAH. Conventional sewage treatment processes reduce the levels of carcinogenic PAH up to 90%; percolating filters and activated sludge processes give a 97%-99% reduction, and coagulation and flocculation also achieve a high reduction. Although the solubility of PAH in water is very low, the presence of organic solvents from industrial effluents can enhance the solubility. Many aspects of the occurrence, formation, and degradation of PAH compounds need investigation to help ensure that the water quality achieved is safe for man.

8. THE ASBESTIFORM-FIBER CONTAMINATION OF LAKE SUPERIOR AND THE RESULTING POTENTIAL HEALTH HAZARD: AN I'..ERPRETATION OF INTERLOCKING PHYSICAL AND HUMAN GEOGRAPHICAL SYSTEMS (MEETING ABSTRACT).

Wepfer AJ
Univ. Oklahoma, Norman, OK 73069
Diss Abstr Int B; 38(4):1635B-1636B 1977

In recent years the United States has witnessed a rising concern over the degradation of the physical environment caused by industrial pollution - especially when, among the ramifications of such pollution, there are potential hazards to human health. Such is the case with the asbestiform-fiber contamination of Lake Superior waters resulting from the operation of Reserve Mining Company's taconite beneficiation plant at Silver Bay, Minnesota. The waste products - taconite tailings - from the mining and processing systems are discharged into the Lake Superior ecosystem at the rate of 67,000 tons per day. Circulatory processes distribute the fiber-bearing tailings throughout the western arm of Lake Superior, thus facilitating the entry of the asbestiform fibers - potential carcinogenic agents - into the municipal water systems of shoreline communities. As a result, consumers are exposed to a potential carcinogen via the drinking of contaminated Lake Superior water. Furthermore, there exists the "hidden" hazard of ingesting food and beverage products manufactured using asbestiform-fiber contaminated water and made available to the public via the marketing/distribution system. To illustrate the geographic patterns of exposure to a "hidden" health hazard, the dissertation focuses on the spatial distribution of food and beverage products manufactured in Duluth, Minnesota. The Duluth Problem is illustrative of the majority of environmental pollution cases in that it is characterized by multi-variate components and complex interactions among interlocking physical and human geographical systems. At the interfaces of the interlocking systems are "channels of ignorance" which allow the passage of pollutant from one system to the next. Only through the recognition and elimination of channels of ignorance can pollution systems be regulated. The regulation of a pollution system lies not within the system itself, but within the higher-order systems constituting the environment within which the pollution system operates. Thus, it is with these higher-order systems - the engineering, environmental, and medical sciences; and the social, economic, and political systems - that those persons charged with environmental policy-making must contend. (Author abstract) (no Refs)

9. ASBESTOS IN POTABLE WATER (MEETING ABSTRACT).

Hallenbeck WH, Hesse CS, Chen EH, Patel-Mandlik K, Wolff AH
Water Resources Center, Illinois Univ. at Urbana-Champaign, IL
Gov Rep Announce Index; 77(13):187 1977

Several published reports indicate that asbestos is found in public drinking water supplies. In order to determine the health effects of ingested asbestos, relevant animal and human studies were reviewed. From these studies, it was not possible to predict potential health hazards associated with ingestion of the levels of asbestos found in drinking water. Detailed examinations of water samples were carried out by electron microscopy in order to determine the precision of analysis for waterborne asbestos. Asbestos-cement pipes, used to transmit drinking water, were studied under field conditions. No significant release of asbestos was observed. Preliminary work suggests that asbestos is present in Lake Michigan. An investigation of possible sources of asbestos in Lake Michigan indicated that wet deposition of asbestos may be a prinicipal pathway of asbestos contamination of Lake Michigan. A feasibility study was carried out to determine if asbestos is present in rainwater collected in the Chicago area. Chrysotile asbestos was found in Chicago rainwater at a level of 10^{7}-10^{8} fibers liter. This finding demonstrates that precipitation scavenges airborne chrysotile asbestos which may result in the contamination of surface waters. (no Refs)

10. ASBESTOS IN POTABLE-WATER SUPPLIES.

Olson HL
Public Water Pipe Div., Johns-Manville Sales Corp., Denver, Colo.
J Am Water Work Assoc; 66(9):515-518 1974

The significance of the presence of asbestos in drinking water (due to the increased use of asbestos-cement pipes) is discussed. Inhalation or direct feeding of asbestos ducts have failed to produce gastrointestinal (GI) cancer in experimental animals. USPHS records show that the incidence of GI cancer in the US had been declining steadily during a period in which asbestos-cement pipe sales have been increasing. The level of asbestos in water-source samples transported through asbestos-cement pipes is very low and Johns-Manville has developed a procedure for checking the asbestos content of water samples using an electron microscope. In a study of water from nine cities, the fiber content of water flowing through asbestos-cement pipes was 1-6 microg/gallon. The author concludes that there is no indication that water conveyed in asbestos-cement pipes constitutes a health hazard.

11. EMISSIONS OF ARSENIC IN SWEDEN AND THEIR REDUCTION.

Lindau L

Natl. Swedish Environment Protection Board, Technical Dept., Industry Div. 2, Fack, S-171 20 Solna, Sweden

Environ Health Perspect; 19:25-29 1977

The environmental pollution attributable to arsenic and the transport and flow of arsenic in Sweden were studied. The study showed that the major source of environmental arsenic was the copper smelters who were also the main users of arsenical materials. Measurements of arsenic in air, water and soil were summarized and the concentrations near a smelter, in the Baltic sea water, and in clean-air areas as well as cities were given. (2 Refs)

12. ARSENIC LEVELS IN OREGON WATERS.

Whanger PD, Weswig PH, Stoner JC

Dept. Agricultural Chemistry, Oregon State Univ., Corvallis, OR 97473

Environ Health Perspect; 19:139-143 1977

An investigation of the arsenic levels in Oregon's waters is presented. In some areas arsenic well water content was 30 to 40 x greater than the United States Public Health Service Drinking Water Standard of 1962 (concentrations exceeding 50 ppb). The arsenic-rich ground water problem is probably due to volcanic deposits. Arsenic-rich wells located in Lane County, are in an area overlying the Fischer Formation, a particular group of sedimentary and volcanic rocks. The highest arsenic concentration is found in the central and eastern portions (young parts) of this formation. Water from the deeper wells generally has more arsenic in it (up to about 2000 ppb). City waters contain no more than 6 ppb arsenic, probably because the water is obtained from lakes, rivers, or reservoirs. Arsenic blood levels of some Oregon residents ranged from a mean of 32 ppb to 251 ppb. No relationship was found between the arsenic levels in water and incidence of skin cancer. Examples of possible arsenic poisoning are presented to demonstrate the difficulty in diagnosing arsenic toxicity. (12 Refs)

13. ARSENIC SPECIES IN DRINKING WATER (MEETING ABSTRACT).

McCurdy RF, Hindmarsh JT

Trace Metal Res. Group, Dept. Pathology, Dalhousie Univ., Halifax, Nova Scotia

Clin Biochem; 11(2):P5-P6 1978

Although the Canadian Drinking Water Standard quotes 0.05 ppm as the max acceptable limit for total arsenic in drinking water, no comment is made about the different chemical forms of arsenic found in water although these are known to vary in toxicity. Toxic amounts of arsenic have been found in well-water supplies in Nova Scotia. We are now investigating the different chemical species of arsenic in these wells using differential extraction and flameless atomic absorption for the inorganic forms and gas chromatographic separation of the respective arsines derived from organic arsonic acids followed by silica furnace atomic absorption quantitation for the organic forms. From the results, which are presented in tabular form, it is obvious that the relative proportions of different arsenic species can vary greatly in drinking water samples. Possible etiological factors and toxicological consequences are being considered.

14. N-NITROSAMINE FORMATION FROM ATRAZINE.

Wolfe NL, Zepp RG, Gordon JA, Fincher RC

Southeast Environmental Res. Lab., U.S. Environmental Protection Agency, Athens, GA 30601

Bull Environ Contam Toxicol; 15(3):342-347 1976

The N-nitrosamine of the pesticide atrazine was studied because (a) N-nitrosamines are potent carcinogens in humans, (b) atrazine is the most widely used pesticide in the U.S. and (c) it has been found in the drinking water in New Orleans and the Midwest. Synthetic reaction conditions yielded 2-chloro-4-(N-nitroso-N-ethylamino)-6-isopropylamino-s-triazine (NNA). (Two other expected products were not isolated) The compound was characterized and a structure assigned. Maximum formation occurred at pH 1.8, and the reaction mechanism seemed to be third-order. NNA kinetics were compared to those of N-nitrosamines formed from other pesticides. NNA was extremely stable in any water solutions above pH 4; however, it was rapidly decomposed by light. This instability in light may prevent the buildup of NNA in environmental samples. Therefore, the most likely location for formation of NNA is in the soil. Studies have demonstrated that atrazine and probably NNA (since it is more water-soluble than atrazine) are widespread in groundwaters of the Midwest as a result of leaching from the soil.

15. FORMATION OF DIMETHYLNITROSAMINE IN POLLUTED ENVIRONMENT AND THE ROLE OF PHOTOSYNTHETIC BACTERIA.

Kobayashi M, Tchan YT

Dept. Agricultural Chemistry, Dyoto Univ., Kyoto 606, Japan

Water Res; 12(3):199-201 1978

Incubation of sludge with a fish meat medium, to simulate a polluted environment, revealed that dimethylnitrosamine (DMN) was formed during putrefaction. However, this compound was metabolized upon addition of the photosynthetic bacteria Rhodopseudomonas capsulata to the medium. Rats were then given DMN in their drinking water with or without the bacteria. Liver tumors were prevented in rats receiving DMN + R. capsulata. (11 Refs)

16. AN ASSESSMENT OF HUMAN EXPOSURE TO N-NITROSO COMPOUNDS.

Fine DH

Thermo Electron Res. Center, Waltham, MA

IARC Sci Publ; (19):267-278 1978

Current knowledge concerning nitrosamine (NA) impurities is reviewed, and data on known exposure routes are normalized to their relative significance in terms of NA exposure per person per day. Volatile NA's are ingested in nitrite-preserved foods; data are not available for the occurrence of nonvolatile NA's in foods. N-Nitrosodimethylamine is present in wastewater from chemical factories at levels of 0.2-5 ug/liter, but the less than 0.01-ug/liter levels of NA'a found in drinking water are considered insignificant. Airborne NA's are inhaled in localized areas around certain specialized industries, tobacco smoke, aqueous mists of herbicides, and cutting fluid vapors. Dermal contact is experienced by machinists who handle machine parts that are wet with cutting fluid, agricultural workers who formulate or apply herbicides, and by persons (especially actresses and models) who use facial cosmetics, hair shampoos, hand lotions, and skin creams. All of these substances contain significant amounts of NA's. Tumors have been induced in laboratory animals by po administration of precursor amines + nitrite, presumably via in vivo nitrosation. In vivo nitrosation also takes place in humans fed diphenylamine + nitrite. Possible N-nitrosation mechanisms are presented. A high pH does not necessarily minimize the reaction, and in vivo nitrosation proceeds at a rate considerably faster than the one that could be predicted by conventional kinetics. (37 Refs)

17. N-NITROSODIETHYLAMINE. (PP. 83-124)
IARC Working Group
Lyon, France
Some N-Nitroso Compounds. Magee PN, Chairman, International Agency for Research on Cancer, Switzerland. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Vol. 17, 365 pp., 1978.

Biological data relevant to an evaluation of carcinogenic risk to humans are presented for N-nitrosodiethylamine (NDEA). The compound has been reported to occur in the air (one area of Baltimore), tobacco smoke, well-water, the waste water from 2/19 chemical plants, various types of food, animal feed, and alcoholic beverages. NDEA is carcinogenic in all animal species tested: mice, rats, rabbits, dogs, gerbils, pigs, monkeys, hedgehogs, various fish, frogs, birds, and Syrian golden, Chinese, and European hamsters. It induces benign and malignant tumors after administration by various routes, including ingestion, parenteral injection, inhalation, and rectal instillation. The major target organs are the liver, respiratory and upper digestive tracts, and the kidney. NDEA is also carcinogenic following administration prenatally and in single doses. Dose-response relationships were established in several studies. A metabolite, N-nitroso-N-ethyl-N-(2-hydroxyethyl)amine, produces mainly liver tumors after po administration to rats. NDEA was found to be mutagenic in several types of assays. The general population may be exposed to low levels of NDEA; however, no exposed group suitable for an epidemiological investigation has been identified. No human data are available. Because of the evidence of its carcinogenicity in many animal species, NDEA should be regarded as if it were carcinogenic to humans. (203 Refs)

18. N-NITROSODI-N-PROPYLAMINE. (PP. 177-189)
IARC Working Group
Lyon, France
Some N-Nitroso Compounds. Magee PN, Chairman, International Agency for Research on Cancer, Switzerland. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans, Vol. 17, 365 pp., 1978.

Chemical and physical data and the results of carcinogenicity and related studies are given for N-nitrosodi-n-propylamine (NDPA), a compound that has been found in the wastewater from 3/28 chemical plants, cheese, alcoholic beverages, and in two pesticides Treflan (trifluralin) and isopropalin. NDPA is carcinogenic in rats after po administration and in rats and hamsters after sc injection, producing benign and malignant tumors of the liver, kidney, esophagus, and respiratory tract. The metabolite N-nitroso-N-(2-hydroxy-n-propyl)-n-propylamine produces benign and malignant tumors of the respiratory tract and liver upon sc injection into rats and hamsters. NDPA was mutagenic in Salmonella typhimurium, Escherichia coli, and Chinese hamster V79 cells. The general population may be exposed sporadically to low levels of NDPA, but there are not human data available. Reports of relatively high levels in Treflan (154,000 and 190,000 ug/liter) may permit the identification of exposed groups. There is sufficient evidence of a carcinogenic effect of NDPA in two animal species; therefore, the compound should be regarded as if it were carcinogenic to humans. (47 Refs)

19. N-NITROSOPIPERIDINE. (PP. 287-301)
IARC Working Group
Lyon, France
Some N-Nitroso Compounds. Magee PN, Chairman
International Agency for Research on Cancer, Switzerland. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans., Vol. 17, 365 pp., 1978.

An evaluation of the carcinogenic risk of N-nitrosopiperidine (NPIP) to humans is presented. NPIP has been found in tobacco smoke, wastewater from chemical factories, cheeses, smoked codfish, various processed and preserved meats, dry, premixed cures containing spices and sodium nitrite and animal feed. In mice, NPIP causes benign and malignant tumors of the liver, lung, forestomach, and esophagus. In rats, NPIP causes tumors of the liver, esophagus, and respiratory system. In addition, it produces tumors of the upper digestive tract, respiratory system, and liver in hamsters and hepatocellular carcinomas in monkeys. Single doses of NPIP are carcinogenic in mice and hamsters. No case reports or human epidemiological data are available. Since the general population may be exposed sporadically to low levels of NPIP and since the animal evidence is conclusive, NPIP should be regarded for practical purposes as if it were carcinogenic to humans. (59 Refs)

20. N-NITROSOPYRROLIDINE. (PP. 313-326)
IARC Working Group
Lyon, France
Some N-Nitroso Compounds. Magee PN, Chairman
International Agency for Research on Cancer, Switzerland. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans., Vol. 17, 365 pp., 1978.

Data on the carcinogenicity of N-nitrosopyrrolidine (NPYR), a compound formed during the heating of N-nitrosoproline, are presented. NPYR has been found in the vapor produced during the frying of bacon, tobacco smoke, waste water from chemical factories, grilled and fried bacon, dry premixed cures containing spices and sodium nitrite, animal feed, and cured lunchmeats, ham, and sausage. Of 40 mice given NPYR po (total dose, 0.015 g/mouse), 4/34 surviving animals had 51 lung adenomas. Of 25 BD rats given 5 or 10 mg/kg/day in the drinking water for 150 days and then double these doses, 23/25 animals developed hepatocellular carcinomas after an av induction time of 470 and 290 days, respectively (av total doses causing tumors in 50% of rats, 3.9 or 4.2 g/kg). In other rat species, hepatocellular carcinomas, papillary mesotheliomas of the tunica vaginalis, interstitial cell tumors, a cavernous hemangioma of the testes, cholangiocarcinomas, and olfactory carcinomas were observed. In Syrian golden hamsters, sc administration of NYPR induced lung tumors. A dose-response relationship was established in rats. NPYR produced reverse mutations in Escherichia coli and Salmonella typhimurium and 8-azaguanine-resistant mutants in Chinese hamster V79 cells. Although no human data are available, there is sufficient evidence of a carcinogenic effect in rats for NPYR to be regarded as if it were carcinogenic to humans. (51 Refs)

21. NITRITE AND NITROSABLE AMINO COMPOUNDS IN CARCINOGENESIS.
Sander J, Schweinsberg F, LaBar J, Burkle G, Schweinsberg E
Hygiene-Institut der Universitat Tubingen, D-74 Tubingen, W. Germany
Gann Monogr Cancer Res; (17):145-160 1975

In addition to nitrite, which is generally used as an indicator of water pollution, amines and amides are also known to occur in water, waste water, or in water-bearing soil strata. Nitrite may react with amines and amides present in the soil. Nitrosamines can be absorbed from the soil by plants. Secondary amines of low or moderate basicity can induce tumors when fed concurrently with nitrite to mice or rats. To this group belong N-methylaniline (carcinomas of esophagus), N-methylbenzylamine (carcinomas of esophagus and

forestomach), and morpholine (carcinomas of liver). Nitrosamines can be synthesized in the human stomach, as shown by analysis of the gastric content of 31 individuals who had received 300 mg sodium nitrate, 1,000 mg glucose, and 10 mg diphenylamine. It is not known whether nitrosamine formation in the stomach of smokers plays a role in the carcinogenesis caused by smoking. Nitrosonornicotine (the most likely nitroso derivative formed in vivo from precursors in tobacco smoke) cannot be detected in the gastric juice of smokers. Application of nitrite and amino compounds to rats and mice results in the same tumors obtained with the corresponding N-nitroso compounds. One cannot at present draw a direct correlation between cancer in man and environmental N-nitroso compounds. (59 refs)

22. CONTAMINATION OF GROUND WATER BY SEWAGE FROM GALVANIC PLANTS.

Csanady M
Staatliches Institut fur Hygiene, Gyali utea 2-6, H-1966 Budapest, Hungary
Z Gesamte Hyg; 23(2):100-102 1977

The pollution of underground water by heavy metal containing sewage from small galvanic plants in rural areas is discussed. Chromium, cyanide, nickel and cadmium were the most prominent heavy metal pollutants, with chromium showing the quickest dispersion rate from the contaminating source followed by nickel and copper at slower rates. The elimination capacity of soil for certain heavy metals is too small to prevent contamination of the water table when high levels of these metals appear in sewage. Limiting values for heavy metal concentrations in sewage must be established. (no Refs)

23. GLOBAL DISTRIBUTION OF CARCINOGENIC POLLUTANTS IN WATER.

Kraybill HF
Cancer Cause and Prevention, NCI, Bethesda, MD 20014
Ann NY Acad Sci; 298:80-89 1977

Data are presented on the concentrations of recognized or suspected carcinogens identified in drinking water supplies in the US, Netherlands, and Canada. Organic carcinogenic contaminants found in water supplies worldwide are listed. Geographic variations in the distribution of environmental pollutants, the biomedical significance of carcinogenic contaminants, and directions for future research are discussed. The presumptive evidence of carcinogenicity from studies on marine animals should be linked with epidemiologic surveys on cancer incidence by organ sites and by regional areas. Further studies on concentrated mixtures and fractions of water contaminants are also necessary to establish causal relationships to cancer. (35 Refs)

B. Monitoring and Analysis of Carcinogenic Contaminants of Water Supplies

24. MONITORING OF POLYNUCLEAR AROMATIC HYDROCARBONS IN WATER. I. EXTRACTION AND RECOVERY OF BENZO(A)PYRENE WITH POROUS POLYURETHANE FOAM.

Saxena J, Kozuchowshi J, Basu DK
Center for Chemical Hazard Assessment, Syracuse Res. Corporation, Syracuse, NY 13210
Environ Sci Technol; 11(7):682-685 1977

The removal of trace quantities of benzo(a)pyrene (BaP) from water using a flexible polyurethane foam plug is reported. The sorption of BaP was performed on three types of foam plugs under static and flow conditions. Retention under static conditions was linear over a range of BaP concentrations covering 20-500 microg/liter. The plugs differed only to a small extent in their sorption characteristics under the two conditions. The recovery of BaP from spiked distilled and tap water at ambient temperature was 91 and 65%, respectively. The decreased retention from tap water appeared to be linked to the presence of suspended particles. The diameter of the column holding the plugs had a distinct effect on BaP recovery. As the column diameter increased, the recovery of BaP decreased. Flow rate had no effect on the efficiency of the foam plugs. The most dramatic effect on the recovery of BaP from spiked tap and distilled water was seen when the temperature of the water was varied. The relationship between BaP recovery and temperature was biphasic. Retention steadily increased with increase in temperature up to 40 C, and decreased with further increases in temperature. When the temperature was increased beyond 50 C, the increase in BaP retention was resumed until a plateau was reached at 60 C. (21 Refs)

25. METHOD DEVELOPMENT AND MONITORING OF POLYNUCLEAR AROMATIC HYDROCARBONS IN SELECTED U.S. WATERS. FINAL REPORT, 1 AUGUST 1975 - 31 JULY 1977.

Saxena J, Basu DK, Kozuchowski J
Syracuse Res. Corp., Syracuse, NY
Method Development and Monitoring of Polynuclear Aromatic Hydrocarbons in Selected U.S. Waters. Final Report, 1 August 1975 - 31 July 1977. Available Through National Technical Information Service, Springfield, Va., as PB-276 635/0GA., EPA/600/1-: 97 pp., 1977.

A method for concentration of trace quantities of the six representatives of the polynuclear aromatic hydrocarbon (PAH) family has been developed and successfully applied to PAH monitoring in finished and raw waters. PAH are collected by passing water through polyurethane foam plugs. Water is heated to 62 +- 2 C prior to passage and flow rate is maintained at approx 250 ml/min to obtain quantitative recoveries. The collection is followed by elution of foam plugs with organic solvent, purification by partitioning with solvents and column chromatography on Florisil, and analysis by two dimensional thin layer chromatography-fluorometry and gas-liquid chromatography-flame ionization detector. Employing this method and a sample volume of 60 liters, PAH have been detected in all the 10 water supplies sampled. Although the sum of the six representative PAH in drinking waters was small (0.9 to 15 parts per trillion (ppt), the values found for raw waters were as high as 600 ppt. It is unclear if PAH are removed during treatment or transformed to another product and escape detection. (Author abstract)

26. MONITORING PROCEDURES FOR CHEMICAL CARCINOGENS IN COASTAL WATERS.

Dunn BP, Stich HF
Cancer Res. Centre, Univ. British Columbia, Vancouver, B.C., Canada
J Fisheries Res Board Canada; 33(9):2040-2046 1976

The contamination of coastal waters by polycyclic aromatic hydrocarbon carcinogens was studied by extraction and purification of hydrocarbon fractions from marine sediments or organisms and determination of compounds by thin-layer chromatography and fluorimetry, or gas chromatography. Sediment samples in the vicinity of a sewage outfall showed elevated levels of benzo(a)pyrene (BaP). Mussels (Mytilus edulis) from the outer Vancouver harbor showed lower BaP levels in the summer than in the winter; this could have been due to seasonal discharges of sewage and storm drain water into the harbor. Elevated levels of BaP in mussels growing near creosoted timbers or pilings suggested that creosote may be a significant source of BaP in the marine environment. This suggestion was supported by comparing gas chromatography profiles of polycyclic aromatic hydrocarbons isolated from mussels and creosoted wood. (1 Refs)

27. ANALYTICAL PROBLEMS IN MEETING WHO LIMITS FOR PAHS IN WATER.

Crathorne B

Water Res. Centre, Medmenham Lab., P.O. Box 16, Henley Road, Medmenham, Marlow, Buckinghamshire, SL7 2HD, England

Proc Analyt Div Chem Soc; 15(5):155-158 1978

Problems involved in analyzing drinking water for polycyclic aromatic hydrocarbons (PAH) in order to meet the World Health Organization's standard of a max 200 nanograms/liter for total PAH are discussed. Total PAH refers to the sum of the levels of six specified PAH. The choice of these PAH makes it difficult to apply alternative analytical techniques to improve the accuracy of the data. (6 Refs)

28. SEPARATION BY HIGH PERFORMANCE LIQUID CHROMATOGRAPHY OF POLYNUCLEAR AROMATIC HYDROCARBONS LISTED BY THE WORLD HEALTH ORGANISATION AS POLLUTION INDICATORS IN DRINKING WATER.

Hunt DC, Wild PJ, Crosby NT

Dept. Industry, Lab. Government Chemist, Cornwall House, Stamford St., London SE1 9NQ, England

Water Res; 12(8):643-644 1978

The use of high-performance liquid chromatography as a separation technique for polynuclear aromatic hydrocarbons (PAH) is reviewed. The development of a new packing material, phthalimidopropyltrichlorosilane (PPS) bound to microparticulate silica, is mentioned and comparisons with other materials are made. A non-polar mobile phase, toluene hexane in a 1:10 ratio, may allow successful separation of the six PAH compounds cited by the World Health Organization as representative drinking water pollutants. (4 Refs)

29. TRACE ANALYSIS OF 3,3'-DICHLOROBENZIDINE IN ANIMAL CHOW, WASTEWATER AND HUMAN URINE BY THREE GAS CHROMATOGRAPHIC PROCEDURES.

Bowman MC, Rushing LG

Dept. Health, Education, and Welfare, Food and Drug Admin., Natl. Center Toxicological Res., Jefferson, AR, 72079

Arch Environ Contam Toxicol; 6(4):471-482 1977

Three gas chromatographic procedures for analyzing trace amounts of 3,3'-dichlorobenzidine and its dihydrochloride salt in animal chow, waste water, and human urine are described. With the use of spiked samples of these compounds, the respective minimal detectable residues were approx 3 ppb, 18 parts per trillion (ppt), and 60 ppt. (15 Refs)

30. BEHAVIOR OF BENZIDINE AND OTHER AROMATIC AMINES IN AEROBIC WASTEWATER TREATMENT.

Baird R, Carmona L, Jenkins RL

County Sanitation Districts, Los Angeles County, Whittier, CA

J Water Pollut Control Fed; 49(7):1609-1615 1977

Activated sludge samples taken from two treatment facilities were dosed to contain 1-, 10-, 20-, 40-, 100-, 250-, or 500-mg/liter concentrations of the carcinogen benzidine or 20 mg/liter of other aromatic amines found in industrial wastes. Using conventional Warburg bioassay techniques, benzidine, o-tolidine, bianisidine, tetramethylbenzidine aniline, and dimethylaniline showed inhibitory effects on the oxygen uptake of the sludge. Analysis by gas-liquid chromatography indicated that most amines showed significant depletion, even when highly toxic, after exposure to the sludge for 6 hr. However, N,N-substituted amines were not depleted much and remained quite toxic. For the monoaromatic amines, an unsubsitituted position ortho- or para- to the -NH2 appeared to be required for electrophilic attack. During the Warburg treatment of b ·zidine, none of the suspected carcinogenic oxidation products persisted. Metabolic intermediates appear to be responsible for the toxicity as well as carcinogenicity of the amines. (17 Refs)

31. ADSORPTION OF PCB'S AND DDT'S ON MEMBRANE FILTERS - A NEW ANALYSIS METHOD.

Kurtz DA

Pesticide Res. Lab., Pennsylvania State Univ., University Park, PA 16802

Bull Environ Contam Toxicol; 17(4):391-398 1977

A new adsorption method is described by which polychlorinated biphenyl (PCB) mixtures, isomers of 1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane (DDT), and other chlorinated hydrocarbons can be separated from water sources. The adsorption medium is a cellulose triacetate membrane filter that is extracted with hexane and/or acetonitrile. Data are presented on the percentage recoveries of PCB's and DDT isomers from a membrane after filtration of a water spike and after direct spiking. Recoveries of Aroclor 1242 after filtration of the water spike ranged from 78% to 118% over three levels of application and those of Aroclor 1254 from 41% to 69%. Recovery of p,p'-DDT and 1,1-dichloro- 2,2-bis(p-chlorophenyl)ethylene (p,p'-DDE) averaged 45% to 59% and 54% to 74%, respectively. Direct membrane spiking yielded a recovery of 16% to 66% for Aroclor 1242 and 32% to 92% for Aroclor 1254; recovery results were lower for p,p'-DDT, o,p'-DDT, p,p'-DDE, and 1,1-dichloro-2, 2-bis (p-chlorophenyl)ethane. The applications of the method for field sampling and for purification of contaminated water sources are discussed. (21 Refs)

32. DIRECT AQUEOUS INJECTION GAS CHROMATOGRAPHY-MASS SPECTROMETRY FOR ANALYSIS OF ORGANOHALIDES IN WATER AT CONCENTRATIONS BELOW THE PARTS PER BILLION LEVEL.

Fujii T

Div. Chemistry and Physics, Natl. Inst. Environmental Studies, Yatabe, Tsukuba, Ibaraki 300-21, Japan

J Chromatogr; 139(2):297-302 1977

A rapid and precise method for the determination of organohalides in the concentration range of 0.1-50 ppb in water samples is described. The method involves the use of mass fragmentographic gas chromography-mass spectrometry and direct aqueous injection of a large sample (100 microliters) on the column (diglycerol as a liquid phase); no concentration or extraction required. Tap water samples from five locations in Japan were found to contain numerous organohalides, the concentrations of which were determined. (Author abstract) (11 Refs)

33. MEASUREMENT OF ENVIRONMENTAL NITROSAMINES.

Cohen JB, Bachman JD

Natl. Enforcement Investigations Center, Office Enforcement, U.S. Environmental Protection Agency, Denver, CO

IARC Sci Publ; (19):357-372 1978

The results of a sampling program designed to identify sources of direct emission of nitrosamines (NA's) into the environment and to assess environmental formation of NA's are presented. Samples were taken during summer and winter in the proximity of industrial plants, primarily sources of amines, and analyzed for NA's. There was little indication of the presence or formation of N-nitroso compounds in the air in the vicinity of the sources examined, even when these comp-

ounds were observed in plant wastewater. The wastewater samples indicated that N-nitroso compounds are present in chemical, pesticide, and coke plant effluents, some persistently. The in situ sampling did not prevent any evidence to substantiate secondary production in the vicinity of amine sources. There were no data that would indicate the formation of NA's in the environment, as opposed to their presence as a contaminant. Data collected along and transverse to major highways showed no contribution of NA's from engine exhaust. The presence of NA's in deionized water (introduced by the mixed-bed resins used for deionization) constitutes a potential, long-term risk for the general population. (9 Refs)

34. N-NITROSO COMPOUNDS IN AIR AND WATER. (PP. 401-408)

Fine DH, Rounbehler DP, Belcher NM

Environmental N-Nitroso Compounds Analysis and Formation Proceedings of a Working Conference held at the Polytechnical Institute, Tallinn, Estonian SSR, 1-3 October 1975. International Agency for Research on Cancer Lyon France, IARC Scientific Publications No. 14, 1976.

The environmental distribution of both volatile and nonvolatile N-nitroso compounds in air and drinking water were determined using the N-nitroso compound-specific thermal energy analyzer interfaced to both a gas chromatograph and a liquid chromatograph. Air samples were collected from specific sites in five cities. Nitrosodimethylamine (NDMA) levels varied from 0.033 to 0.96 microg/k in air samples taken in an industrial area of Baltimore, Maryland. Air in Belle, West Virginia, contained 0.014-0.051 microg/kg NDMA. No detectable levels were found in Philadelphia, Pennsylvania; Wilmington, Delaware; or Waltham, Massachusetts. Drinking water samples were obtained from several water plants in the New Orleans, Louisiana area and from the Mississippi River. The water showed several peaks which may correspond to N-nitroso compounds. The concentrations were about 0.1 microg/kg for the major peaks. Several N-nitroso derivatives of pesticides gave peaks which matched those obtained from water. (7 refs)

35. CHROMATOGRAPHIC DETERMINATION OF VOLATILE N-NITROSAMINES IN NATURAL AND WASTE WATERS.

Kosmenko LD, Kostenko VG

N. N. Petrov Res. Inst. Oncology, Leningrad, USSR

Gig Sanit; (2):53-57 1979

The efficacy of various chromatographic techniques for the detection of volatile nitrosamines in bodies of water and wastewater was tested. Four dialkylnitrosamines, dimethylnitrosamine (DMNA), diethylnitrosamine (DENA), di-n-propylnitrosamine (DPNA), and di-n-butylnitrosamine (DBNA), were analyzed in water samples from the Neva River at Leningrad and in wastewater samples from a hydrolysis plant. The most reliable results were obtained with the simultaneous use of gas-liquid or liquid chromatography and spectrophotometry. The Neva River water contained less than 5 ug/ml DMNA, DENA, DPNA, or DBNA, the wastewater less than 20 ug/ml. (15 Refs)

36. TRACE ORGANIC CONTAMINANTS IN DRINKING WATER; THEIR CONCENTRATION BY REVERSE OSMOSIS.

Deinzer M, Melton R, Mitchell D

Environmental Health Sciences Center, Dept. Agricultural Chemistry, Oregon State Univ., Corvallis, OR 97331

Water Res; 9(9):799-805 1975

The reverse osmosis concentration of organic compounds in water was investigated to determine the validity of a solubility-diffusion hypothesis for predicting the rejection of organic compounds by 2.5 cellulose acetate membranes. Pentaerythritol, bis(2-chloroethyl) ether, bis(2-chloroisoprophl) ether, urea, triethylene glycol dipropylamine, chlorobenzene, propylbenzene, and benzonitrile were used as model solutes. Organic contaminants in Cincinnati drinking water were concentrated by a reverse osmosis/lyophilization method and identified by gas chromotography/mass spectroscopy. The classes of organic compounds that were concentrated included hydrocarbons, phthalates, chlorinated compounds, polyethers, and long chain fatty acids or their derivatives. Barbital, phenyl benzoate, and phthalic anhydride were also present. (26 refs)

37. CARCINOGENS AND ANALOGS: TRACE ANALYSIS OF THIRTEEN COMPOUNDS IN ADMIXTURE IN WASTEWATER AND HUMAN URINE.

Nony CR, Bowman MC

Dept. Health, Education and Welfare, Food and Drug Admin., Natl. Center Toxicological Res., Jefferson, AR, 72079

Int J Environ Anal Chem; 5(3):203-220 1978

Traces of 13 carcinogens and related compounds (aromatic amines and estrogens) in admixture in wastewater and human urine were determined by gas chromatography. Residues were detectable at the 0.1-and 1-ppb levels in the two liquids, respectively. Partition values for all pentafluoropropionyl derivatives in five solvent systems, structure verification by mass spectrometry, and adaptation of the method to work surfaces and air are provided. (18 Refs)

38. TRACE ANALYSIS: A REQUIREMENT FOR TOXICOLOGICAL RESEARCH WITH CARCINOGENS AND HAZARDOUS SUBSTANCES.

Bowman MC

Food and Drug Admin., Natl. Center Toxicological Res., Jefferson, AR, 72079

J Assoc Off Anal Chem; 61(5):1253-1262 1978

A scheme for analyzing an admixture of 13 carcinogens and related compounds in human urine, wastewater, and environmental surveillance samples (swabs, air filters, etc) is based on electron capture gas chromatography of their pentafluoropropionyl derivatives. (6 Refs)

39. CHEMICAL AND MUTAGENIC ANALYSIS OF WATER SAMPLES.

Chriswell CD

Ames Lab., Ames, IA

Proceedings of the Meeting on Environmental Mutagenics Held at Bethesda, 9 January 1978. Available from National Technical Information Service, Springfield, Va., as N78-28206, CONF-780131-1, 17 pp., 1978.

Resin extraction procedures for separating organic compounds from drinking water are described along with fractionation procedures. Results of testing water samples for mutagenic activity are given. A description of the defense inhibition procedure is included. (Author abstract)

40. EXTRACTIC[illegible]ND IDENTIFICATION OF ORGANIC MICROPOLLUTANTS: REVERSE OSMOSIS METHOD.

Kopfler FC, Coleman WE, Melton RG, Tardiff RG, Lynch SC, Smith JK

Health Effects Res. Lab., US Environmental Protection Agency, Cincinnati, OH 45268

Ann NY Acad Sci; 298:20-30 1977

Modifications are presented of a previously described reverse osmosis system as applied to the types of organic materials found in drinking water. The sample is concentrated in batches (rather than continuously) so that reservoirs of only 50 gallons can be used instead of 500 gallons. Compounds identified by gas chromatography and mass spectrometry in samples from eight municipal water supplies included 23 plasticizers, 5 natural products and 7 miscellaneous compounds. (12 Refs)

41. PART I. OCCURRENCE AND REMOVAL OF WATER POLLUTANTS. ANALYSIS OF ORGANIC COMPOUNDS IN WATER TO SUPPORT HEALTH EFFECTS STUDIES.

Garrison AW

Environmental Res. Lab., U.S. Environmental Protection Agency, Athens, GA 30601

Ann NY Acad Sci; 298:2-19 1977

Current methods of measuring organic compounds in water are discussed and illustrated by their application to volatile organic pollutants in New Orleans drinking water, purgeables in Miami drinking water, and volatile organics in industrial effluents and municipal sewage. Advances in the analytic methodology for volatile compounds are noted, and suggestions are made for developing analysis of nonvolatile compounds, which account for up to 95% of the total organic material in water. The establishment of the Environmental Protection Agency's computerized library of organic water pollutants is reviewed briefly. (25 Refs)

42. ISOLATION AND IDENTIFICATION OF SOME THERMAL ENERGY ANALYZER (TEA) RESPONSIVE SUBSTANCES IN DRINKING WATER.

Fan TY, Ross R, Fine DH, Keith LH, Garrison AW

Thermo Electron Res. Center, 85 First Ave., Waltham, MA, 02154

Environ Sci Technol; 12(6):692-695 1978

Methylene chloride extracts of finished water samples obtained from several municipal water treatment plants were analyzed by Thermal Energy Analyzer (TEA) high-pressure liquid chromatography. Compounds identified in the water as TEA-responsive substances were further isolated and characterized. Ethylene glycol dinitrate was identified as a TEA responsive substance in the finished water in all three municipalities. The presence of a TEA-responsive substance should therefore not be presumptive evidence for the presence of N-nitroso compounds. (11 Refs)

43. CONCENTRATION AND SEPARATION OF ARSENIC FROM POLLUTED WATER BY ION EXCHANGE.

Sandhu SS, Nelson P

Claflin Coll., Orangeburg, SC, 29115

Environ Sci Technol; 13(4):476-478 1979

A technique for the concentration and separation of arsenic from polluted environmental samples, which contain metal ions reported to interfere with As determination by the silver diethyldithiocarbamate (SDDC) method, is described. Aqueous samples are digested with potassium permanganate and eluted through chromatograph columns packed with Amberlite ion-exchange resin. As retained by the resin is extracted with HCl prior to its determination by the SDDC method. The technique facilitates the quantitative determination of As at levels below 0.005 mg/liter. (18 Refs)

44. TRACE METALS IN MAN'S ENVIRONMENT AND THEIR DETERMINATION BY ATOMIC ABSORPTION SPECTROSCOPY.

Norval E, Butler LR

Natl. Phys. Res. Lab., CSIR, Pretoria, South Africa

S Afr Med J; 48(63):2617-2626 1974

The clinical effects, sources, and techniques for atomic absorption spectroscopy determination of metals in air, water, and biological samples are reviewed. Atomic absorption spectroscopy is a low cost technique for rapid, accurate determination of very small concentrations of metals in the environment. Lead, mercury and cadmium, the chief sources of dangerous environmental pollution, are discussed with regard to their physiological significance and determination methods. The roles of lead, iron, chromium, manganese, vanadium, nickel, zinc, arsenic and beryllium in the etiology of occupational diseases are also discussed. It is concluded that atomic absorption spectroscopy is a useful method for defining the precise functions of metals in metabolism, diagnosing pathological conditions and defining maximum allowable environmental concentrations of trace and macro metals.

45. IDENTIFICATION AND DISTRIBUTION OF INORGANIC COMPONENTS IN WATER: WHAT TO MEASURE?

Glass GE

Environmental Res. Lab., U. S. Environmental Protection Agency, Duluth, MN 55804

Ann NY Acad Sci; 298:31-46 1977

The chemical equilibria model was used to calculate the molecular distribution of inorganic components in Lake Superior water. This distribution was compared with effects on aquatic organisms such as the water flea (Daphnea magna). Nitrilotriacetate and EDTA were found to dominate the aquo chemistry of Cu and Cd, but not Hg. Metals introduced to water as silicate mineral particles contributed little to the total metal tissue content in fish. Analysis of the drinking water in Duluth showed wide variations in Pb, Cl2, NH3, asbestiform fibers, hexafluorosilicic acid, and glass contents at different locations and times. (52 Refs)

46. RADIOLOGICAL SURVEY AT THE INACTIVE URANIUM MILL SITE NEAR RIVERTON, WYOMING.

Douglas RL

Office of Radiation Programs, Las Vegas, NV

Radiological Survey at the Inactive Uranium Mill Site Near Riverton, Wyoming. Office of Radiation Programs, Las Vegas, NV, ORP/LV-77/2: Available through National Technical Information Services, Springfield VA. Document No. PB-271 332/9GA., 33 pp., 1977.

A radiological survey was made of the inactive uranium mill site near Riverton, Wyoming during the period September 30-October 2, 1975. The primary purpose of the survey was to delineate areas which are contaminated by windblown material from the tailings pile. Secondary purposes were to collect water samples from local wells, and to collect indoor radon progeny (working level) samples in structures near the site, in order to identify any major radiation exposures which may be occurring through these exposure pathways. The contaminated areas were delineated by making a series of differential gamma exposure rate measurements at the ground surface. A total of about 460 acres, exclusive of the tailings pile, was found to be contaminated above background levels. An area of 30 acres would have to be decontaminated to reduce the max residal exposure rate to 40 micro R/hr, and 99

acres would haave to be decontaminated to reduce the maximum residual exposure rate to 10 micro R/hr. (Author abstract) (no Refs)

47. PLUTONIUM AND AMERICIUM CONCENTRATION ALONG FRESH-WATER FOOD CHAINS OF THE GREAT LAKES, U.S.A. PROGRESS REPORT, JULY 1976-SEPTEMBER 30, 1977.

Bowen VT
Woods Hole Oceanographic Inst., Woods Hole, MA
Plutonium and Americium Concentration Along Fresh-Water Food Chains of the Great Lakes, U.S.A. Progress Report, July 1976-September 30, 1977. Available Through National Technical Information Service, Springfield, Va., as COO-3568-18:, EY-76-S-02-3568, 28 pp., 1977.

The primary purpose of studying the biogeochemical behavior of transuranic radionuclides in large freshwater lakes began with studies of the distribution of these radionuclides, essentially introduced from the fallout of atmospheric nuclear weapons tests, in Lake Ontario. The recognition that an additional source of supply of these nuclides to Lake Ontario (subsequent to their release into Lake Erie) existed in the form of leakage from the Nuclear Fuel Services reprocessing plant at Springville, New York, led to expansion of the program to include sampling at the eastern end of Lake Erie. Much of the program is devoted to studies of the distribution of these nuclides in the lake sediments as they appear to be a major repository for transuranics in freshwater lakes. The extent to which this is a temporary or permanent repository is illuminated by studies of transuranic distributions in the lake waters and biota. (Author abstract)

48. PLUTONIUM IN DRINKING WATER: EFFECTS OF CHLORINATION ON ITS MAXIMUM PERMISSIBLE CONCENTRATION.

Larsen RP, Oldham RD
Radiological and Environmental Res. Div., Argonne Natl. Lab., Argonne, IL, 60439
Science; 201(4360):1008-1009 1978

Soluble plutonium is oxidized to the Pu(VI) oxidation state by chlorine during water treatment. Under certain conditions Pu(VI) is readily absorbed from the gastrointestinal tract. It appears that due consideration has not been given to the effect that the presence of plutonium in this oxidation state may have on the max permissible concentration of plutonium in drinking water. (Author abstract) (no Refs)

49. TREATMENT TECHNIQUES FOR THE REMOVAL OF RADIOACTIVE CONTAMINANTS FROM DRINKING WATER (MEETING ABSTRACT).

Logsdon GS
Water Supply Res. Div., United States Environmental Protection Agency, Cincinnati, OH, 45268
Health Phys; 35(6):918 1978

Max contaminant levels have been set for radioactive contaminants, required by the Safe Drinking Water Act (PL 93-523). Treatment techniques are available for removing radium and beta-gamma emitters. Presently used methods of removing radium-226 are precipitative lime softening (80-90% removal), ion exchange softening (95% removal) and reverse osmosis (95% removal). The 5 picoCi (pCi)/liter (l) limit for radium can be met with conventional technology for raw waters in the 5-100 pCi/l concentration range. Treatment for removal of beta or gamma emitters must be based upon chemical rather than radioactive characteristics of the contaminant. Reverse osmosis can remove a broad spectrum of ions and molecules from water, so it is the process most likely to be used. The max contaminant level for beta and gamma radioactivity is an annual dose equivalent to the total body or any organ not to exceed 4 millirem/yr. The fate of radionuclides after removal from drinking water should be considered. Presently radium is disposed with other process wastes at softening plants removing radium. Confinement and disposal as a radioactive waste would be very expensive. (no Refs)

50. AN EVALUATION OF THE RADON CONCENTRATION IN NORTH CAROLINA GROUND WATER SUPPLIES.

Sasser MK, Watson JE
U.S. Dept. Energy, Aiken, SC, 29801
Health Phys; 34(6):667-671 1978

Water samples from 225 North Carolina ground water supplies were analyzed to determine the presence of 222Rn. The results are reported in picoCi/liter and range up to a max of 46,000. Approx 33% of the water supplies analyzed were found to have concentrations greater than 200 picoCi/liter, the old standard list by the National Council on Radiation Protection in the National Bureau of Standards Handbook 52. There is currently no standard. A review of health studies concerning the radiation dose received via drinking water containing radon revealed that most authors have considered the stomach to be the critical organ. These studies indicated that a 222Rn concentration in water in the range of 3000-7000 picoCi/liter delivers to the stomach the 0.5 rem/yr dose limit recommended by the International Commission on Radiological Protection for the general population. One study indicated that the inhalation dose resulting from the diffusion of radon from drinking water into the home atmosphere may be even more restrictive than the ingestion dose to the stomach. It is suggested that a standard be set and applied for radon concentrations in water. Radon is poorly soluble in water and may be removed by aeration or other methods to prevent citizens from receiving unnecessary doses. (Author abstract) (11 Refs)

II. EPIDEMIOLOGICAL ASSOCIATIONS OF CONTAMINANTS OF WATER SUPPLIES WITH HUMAN CANCERS

A. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: General

51. THE NEW ORLEANS DRINKING WATER CONTROVERSY. A STATISTICAL PERSPECTIVE.

DeRouen TA, Diem JE
Dept. Biostatistics, Univ. Washington, Seattle, WA 98195
Am J Public Health; 65(10):1060-1062 1975

The report released by the Environmental Defense Fund in November 1974 stating that "over 50 premature deaths from cancer among white males would be averted annually" by purifying or changing the source of the New Orleans water supply is examined. The figures of the report were arrived at by multiple regression analysis. In subsequent analyses by the same group, the water variable differed significantly from zero in regression analyses performed on total cancer for nonwhite men and women and white men, but not for white women. In two analyses in which significance was achieved for the water variable, the coefficient of determination for the entire regression equation was less than 0.15, indicating that the equation accounted for less than 15% of the variability in the cancer mortality rates. Thus the evidence supporting the hypothesis of water as the causative agent shows considerable inconsistency. In addition, the original report indicated that 9 of the 45 US counties having the highest cancer mortality rate were in Louisiana, but overlooked in the regression analysis that 4 of them do not use the Mississippi as a water source.

Another report has used the same data to support a different hypothesis, citing ethnic and geographic differences as causes of variations in cancer mortality in the area. It is concluded that although the hypothesis put forth by the report is plausible, the evidence supporting it is not as strong as the publicity about it might suggest.

52. RELATIONSHIPS BETWEEN CANCER MORTALITY IN LOUISIANA DRINKING-WATER SOURCE AND OTHER POSSIBLE CAUSATIVE AGENTS. (PP. 331-345)

DeRouen TA, Diem JE

Dept. Biostatistics, Univ. Washington, Seattle, WA, 98195

Incidence of Cancer in Humans, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4, Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 602 pp., 1977.

Previous evidence that associated organics in drinking water (DW) from the Mississippi River with cancer mortality in Louisiana for all sites and for cancer of the gastrointestinal (GI) and urinary organs was examined. The association was based on the key assumption that concentrations of carcinogens in Mississippi River water are higher than those in other water supplies in Louisiana. Cancer mortalitiy rates for certain organs, particularly those of the GI track, were higher in areas deriving some or all of their DW from the Mississippi. However, the contention that low concentrations of organics in the DW contributed significantly to the high mortality rates is disputable. Several inconsistencies support this contention. The above key assumption may not be valid, at least as far as the concentration of chloroform, the most prevalent organic in the DW, is concerned. If chloroform played a major role, then liver cancer incidence would be increased, but the liver cancer mortality rates did not demonstrate this effect. Lung cancer risk would not be expected to be affected, but a significant relationship was demonstrated for nonwhite men, and the significance remained even with the addition of three other possible causative variables (regional differences, percentage of the work force engaged in manufacturing-related jobs, and the interaction between the two). However, these three variables, when added to the six independent variables of the original study, eliminated the significance of the DW variable in half of the urinary and GI cancer groups for which it had been significant. More refined measurements of cultural differences and an accurate measure of industrialization may reduce the significance of the DW variable further. These arguments do not disprove the contention that DW is a cause of cancer mortality; however, if organics in the DW did play a major causative role, the discrepancies pointed out would not be likely to exist. (10 Refs)

53. DRINKING WATER AND CANCER MORTALITY IN LOUISIANA.

Page T, Harris RH, Epstein SS

Resources for Future, Inc., 1755 Massachusetts Ave., NW, Washington, DC 20036

Science; 193(4247):55-57 1976

Drinking water and cancer mortality were studied in Louisiana because of suspicions of the possible etiological role of drinking water in the high incidence of bladder cancer in New Orleans, the finding of carcinogens in Mississippi River drinking water and the disparity between the quality of Mississippi River drinking water and other sources in Louisiana. Multivariant regression analysis indicated a statistically significant relation between cancer mortality rates and Mississippi River drinking water. This was true for total cancer, cancer of the urinary organs and cancer of the gastrointestinal tract. Although many factors were not taken into consideration (smoking habits, alcohol consumption), this study indicates that there may be a link between carcinogens in drinking water and cancer mortality. (23 Refs)

54. CANCER MORTALITY IN SELECTED LOUISIANA PARISHES AND DRINKING WATER SOURCE (MEETING ABSTRACT).

Gottlieb M

Tulane Univ., New Orleans, LA, 70112

Am J Epidemiol; 108(3):232 1978

Cancer mortality rates for selected sites are high in Louisiana. Use of the Mississippi River water for drinking has been implicated. A case-control death certificate study of resident deaths and non-cancer deaths from 1960-1975 for selected Louisiana parishes has been undertaken to determine the relationship of water source and characteristics to cancer mortality. Parishes using surface water were paired to parishes using ground water and grouped to obtain an equal frequency of population using ground as surface water and having similar industrialization characteristics. Information on industry of occupation and industry located near residence will be collected and type of water used and dates of use will be verified. The cancer sites of interest are bladder, kidney, prostate, brain, liver, pancreas, rectum, large intestine, esophagus, stomach, lymphoma, multiple myeloma, leukemia, Hodgkin's disease, lung, breast, and malignant melanoma. Cases from a parish group were matched with controls from the same parish group. Preliminary analysis of the first eight sites indicates a pattern of increased relative odds for living in a surface-water-using parish for cancer of bladder, kidney, and rectum, for at least three out of five parish groups. There are differences in risks among parish groups for cancer mortality by site. (no Refs)

55. OHIO DRINKING WATER SOURCE AND CANCER RATES.

Kuzma RJ, Kuzma CM, Buncher CR

Dept. Environmental Health, Div. Epidemiology and Biostatistics, Univ. Cincinnati, Cincinnati, OH 45267

Am J Public Health; 67(8):725-729 1977

Analysis of covariance was used to compare cancer mortality patterns in 88 Ohio counties that were classified as either ground water (GWC) or surface water counties (SWC), based on the source of drinking water used by most residents. Forty-two counties were classified as GWC and 46 as SWC. The cancer mortality rates for white men were significantly higher in SWC than in GWC (5% higher for all cancers and 19% and 18% higher for stomach and bladder cancers, respectively). The stomach cancer mortality rate for white women was significantly higher ($p = 0.038$) in SWC than in GWC. These differences were not attributable to urbanization, median income, population size, or agricultural or manufacturing activity. It is suggested that the surface drinking water supplies contained substances that can cause cancer. (12 Refs)

56. DRINKING WATER AS AN EPIDEMIOLOGIC RISK FACTOR FOR CANCER. (PP. 347-356)

Buncher CR, Kuzma RJ, Forcade CM

Div. Epidemiology and Biostatistics, Dept. Environmental Health, Univ. Cincinnati, Coll. Medicine, Cincinnati, OH, 45267

Incidence of Cancer in Humans, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4, Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 602 pp., 1977.

The effect of drinking water source on cancer incidence in Cincinnati, Ohio, was determined. Comparison of cancer deaths in Cincinnati, which derives its drinking water from the Ohio River, with cancer deaths in other counties along the

river, some of which derive their drinking water from the river, indicated that there were no differences due to drinking water source. Similar results were obtained in Kentucky, West Virginia, and Indiana, as well as in other studies within Ohio. Next, the cancer mortality rate was analyzed by county according to ground or surface sources of drinking water. The cancer incidence was significantly increased in white men living in surface water areas compared with those living in groundwater areas. Bladder cancer was consistently related to drinking water source for white men but not for white women. Stomach cancer was significantly related to drinking water source for white men, and a comparable but smaller effect was observed for white women. The total cancer rate was slightly elevated for white women, but this finding was of borderline significance. Thus source of drinking water (surface or ground) appears to affect cancer incidence. (9 Refs)

57. AN EPIDEMIOLOGIC INVESTIGATION OF THE RELATIONSHIP BETWEEN CHEMICAL CONTAMINANTS IN DRINKING WATER AND CANCER MORTALITY.

Reiches NA
Ohio State Univ., Columbus, OH
Diss Abstr Int B; 38(8):3642-3643 1978

This study was designed to examine the hypothesized relationship between organic chemicals in drinking water and nine site-specific human cancers on a national basis. One hundred eighty seven counties, whose water supplies had been analyzed by the Environmental Protection Agency (EPA), were included in the investigation. Cancer mortality rates for the years 1966-1974 (exclusive of 1972) were analyzed. Additionally, an attempt was made to control for the effects of urbanization, industrialization, education, and income. Multiple regression and correlation analyses failed to confirm statistically the drinking water-cancer relationship. Comparison of these findings with other epidemiologic investigations revealed that there is no support in favor of this hypothesis. Several studies that report positive findings utilized low levels of statistical significance; also, many of the positive findings were dependent on the statistical method employed. Despite the negative or weak findings that have been presented here and elsewhere, there is enough consistency among the accumulated findings to suggest that research in this area be pursued. However, future efforts should focus on alternative study designs that include more precise exposure and control data. This should include the initiation of more specific aggregate population studies as well as the development of case control studies, where feasible. Precision may be introduced to these investigations by the utilization of morbidity data, by studying populations well-defined by exposure level, and by seeking more comprehensive measurements of water quality. (no Refs)

58. ENVIRONMENTAL HEALTH RELATIONSHIPS BETWEEN SOME SELECTED PHYSICO-CHEMICAL PARAMETERS IN DRINKING WATER AND CANCER MORBIDITY IN THE METROPOLITAN AREA OF MINNEAPOLIS - ST. PAUL.

Rodriguez G
Univ. Minnesota, Minnesota, MN, 55455
Diss Abstr Int B; 39(9):4290-4291 1979

A retrospective analysis of cancer incidence by census tract was performed for 22 anatomical sites utilizing the morbidity data provided by the Third National Cancer Survey for the five-county area surrounding the cities of Minneapolis and St Paul. The study included approx 14,000 cancer cases reported between 1969 and 1971 in the white population of Hennepin, Ramsey, Anoka, Dakota, and Washington counties. Out of nine gastrointestinal (GI) and urinary cancers studied, six of these sites (stomach, pancreas, kidney, bladder, esophagus, and liver) have, on the av, higher male incidences for Minneapolis than for St Paul. For females, four of the above cancer incidences remain higher in Minneapolis: rectum, bladder, esophagus, and liver. When a comparison was made between surface water and groundwater, it was found that incidence cancer rates for all GI and urinary sites for both sexes were lower in areas served by groundwater than in areas served by surface waters. Lung and larynx cancers found in both males and females seem to be related to environmental air pollution even when such a gross indicator of air pollution, namely particulate matter, was utilized. Income is a variable that seems to influence cancer incidence and to a lesser extent the percentage of foreign stock in the census tract. The age of the house does not seem to be related to cancer incidence. (2 Refs)

59. THE EPIDEMIOLOGIC APPROACH TO THE EVALUATION OF ORGANICS IN DRINKING WATER.

Cantor KP, McCabe LJ
U.S. Environmental Protection Agency, Cincinnati, OH, 45268
Water Chlorination; 2:379-393 1978

Epidemiologic methods of evaluating the cancer hazard posed by contaminants in drinking water are reviewed, as are some studies that have utilized these methods. The hypotheses upon which a study may be based may originate from laboratory experiments combined with information on environmental exposures to humans, the observations of astute clinicians, and geographical and temporal comparisons of the rates of exposure and disease in human populations. Ecologic studies, which correlate the geographical distribution of disease with environmental factors, are relatively inexpensive and can be completed quickly. However, they have only a limited ability to take account of possible confounding factors and should be used only to provide qualitative guides to risks. Case-control and cohort studies are valuable in testing hypotheses and in developing quantitative estimates of health risks related to particular exposures or personal characteristics. They are, however, more costly and time-consuming than ecologic studies. Several ecologic studies have investigated the potential cancer risk associated with chlorination and/or organics in drinking water supplies. Bladder and colon/rectal cancer mortality was correlated with the water quality parameter in several of these studies. Analytic studies based on information from cancer patients and appropriately matched controls are now imperative to evaluate a possible causal relationship. (23 Refs)

60. CARCINOGENESIS INDUCED BY TRACE CONTAMINANTS IN POTABLE WATER.

Kraybill HF
Div. of Cancer Cause and Prevention, NCI, Bethesda, MD
Bull NY Acad Med; 54(4):413-427 1978

The following are some recognized and suspect carcinogens in US drinking water and their concentrations (in ug/liter, when given): aldrin (5.4), benzene (50), benzo(a)pyrene (0.0002-0.002), bis(2-chloroethyl)ether (0.42), lindane, carbon tetrachloride (2.0-3.0), chlordane (0.1), chloroform (0.1-311), 1,2-dibromoethane, dieldrin (8.0), dichlorodiphenyltrichloroethane (DDT), dichlorodiphenyldichloroethylene (DDE) (0.05), 1,4-dioxane (1.0), endrin (0.004), heptachlor, trichloroethylene, and vinyl chloride (10.0). Of these compounds, benzo(a)pyrene and vinyl chloride are the only recognized carcinogens. Only volatile organic compounds have been identified in US drinking water, and a much larger component of nonvolatile substances remains to be identified or quantified. In city water in the Netherlands and Germany, concentration ranges of inorganic contaminants such as arsenic, cadmium, chromium, and selenium are 1.0-8.1, 2.0-9.0, 4.5-10.0, and 3.1-6.0 ug/liter,

respectively. Asbestiform materials or asbestos particles have been found in many river systems at concentrations greater than 10 ug/gallon. In a study of cancer mortality in 10 river basins in the US, nickel concentrations appeared to correspond with oral and intestinal cancer death rates, arsenic with cancer of the eye and larynx and myeloid leukemia. Beryllium correlated with bone cancer and with mortalities from breast and uterine cancer. Lead was associated with leukemia and lymphoma and with kidney, stomach, intestinal, and ovarian cancer. The results of various epidemiological studies throughout the US are reported. The need for in vitro bioassays to augment in vivo procedures in determining carcinogenicity is stressed. (30 Refs)

61. CARCINOGENIC HAZARDS OF ORGANIC CHEMICALS IN DRINKING WATER. (PP. 309-330)

Harris RH, Page T, Reiches NA

Environmental Defense Fund, Washington, DC, 20036

Incidence of Cancer in Humans, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4, Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 1-602 pp., 1977.

Studies dealing with elevated cancer mortality rates resulting from the presence of carcinogens in the drinking water are reviewed. Five main topics are discussed: (1) organic carcinogens in drinking water, (2) approaches to assessing the potential health consequences of these chemicals, (3) recent epidemiologic studies, (4) statistical problems in relating exposure to water pollutants to cancer mortality, and (5) the application of the results of these epidemiologic studies to assessment of the risk of low-level carcinogenic exposure. Studies indicate that although a wide variety of chemical carcinogens are present in the drinking water, their concentrations are low. However, epidemiologic studies in Louisiana, Ohio, and New Jersey support the hypothesis that carcinogens in drinking water are related to human cancer. Since these findings reflect exposure to carcinogen levels present 20-30 yr ago and present-day levels are assumed to be higher, more noticeable effects may be expected in the future. (38 Refs)

62. EPIDEMIOLOGY OF ENVIRONMENTAL POLLUTION: DRINKING WATER IN RELATION TO CANCER AND HEART DISEASE.

Buncher CR, Kuzma RJ, Forcade CM

University of Cincinnati Medical College, Cincinnati, OH 45267.

Am J Epidemiol; 104(3):358-359 1976

There is an extensive literature relating various factors in the drinking water to heart disease rates. In particular, the hypothesis is often stated that heart disease rates are higher in areas with soft water than in areas with hard water. Literature in this field is reviewed, especially as contrasted to the history of the discovery of the association between mottling of teeth, reduction in rate of caries, and fluoride level in the drinking water. More recently (1974) it was suggested by the Environmental Defense Fund that persons drinking ground water in Louisiana parishes are at less risk of dying of cancer than persons who drink surface (Mississippi River) water. Evidence in favor of this theory and alternative explanations of the data are discussed. The authors have carried out an analysis of the effect of drinking water from the Ohio River. Numerous organic compounds were reported in the drinking water, and some of these compounds are suspected, or proven, carcinogens. The conclusion of this analysis was that no epidemiologic evidence was found that there was any relationship between the drinking water in Cincinnati and the cancer death rates. A recent analysis of source of drinking water for the 88 counties of Ohio provides new information that cancer rates are higher for persons drinking from surface water sources than those drinking from ground water sources. The epidemiologic problem is that source of water is correlated with urban/rural, income, occupational, and other differences. Thus the question becomes one of separating out these different sources so that effects of each can be determined. (Author Abstract)

63. CORRELATION OF CANCER DEATH RATES WITH ALTITUDE AND WITH THE QUALITY OF WATER SUPPLY OF THE 100 LARGEST CITIES IN THE UNITED STATES.

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J Toxicol Environ Health; 3(3):465-478 1977

Data on water treatment and the quality of the finished water supply of the 100 largest US cities (population greater than 60 million) were combined with data on cancer deaths (age-adjusted) of the county or counties in which the cities lie, to look for significant correlations with altitude and with quality of water supply. The previously discovered decrease in cancer rates with increasing altitude (for countries around the world) was confirmed for these cities. Correlation coefficients,-0.46 for men and-0.32 for women, were highly significant (p less than 0.001). The rates were then altitude-adjusted for subsequent analysis. Of the general measures of water quality, the highest correlation was with specific conductivity, total dissolved solids, and hardness; pH was not significantly correlated. Significant correlations were found for $Ca^{2}+$, $Mg^{2}+$, Na+, HCO3, and Cl- concentrations, but not for F-, and NO3-, or K+ concentrations, which were very low. Regression slopes for specific ions were much more uniform in terms of milli-equivalents per liter than parts per million. The reduction in cancer appears to be nonspecific for major sites, as is the previously reported altitude effect. A possible common explanation of the altitude and water-quality correlations is discussed in terms of the acid-base balance and base reserve of the body, but there are no adequate data for the effect of increased dissolved solids in water on blood chemistry to support speculation. A regression equation combining the altitude and the specific conductivity of the water of these cities predicts the death rate from cancer to the 95% level of confidence, within +- 17.4% for men and +-17.0% for women. Of the total variance in death rates, 36% is associated with these two parameters combined. (13 Refs)

64. GEOGRAPHIC CLUSTERING OF BRAIN TUMORS IN KENTUCKY.

Brooks WH

U. Kentucky Med. Sch., Lexington, KY

Cancer; 30(4):923-926 1972

An attempt was made to determine the geographic distribution of 612 brain tumors reported in Kentucky from 1963-1969. A geographic cluster was revealed in the eastern section of the state when the tumors were grouped according to county and adjusted for population. The incidence of all brain tumors within these six counties was 3.37 times that of the remainder of the state; the incidence of gliomas within the area was 4.4 times that expected. Within the counties, 66.1% of cases were located along major tributaries of the Kentucky and Licking Rivers. The possibility of contamination of water with chemical carcinogens is suggested as an environmental factor in the production of primary intracranial neoplasms.

65. STOMACH CANCER MORTALITY IN THE NORTH CENTRAL STATES: HIGH RISK IS NOT LIMITED TO THE FOREIGN-BORN.

Kriebel D, Jowett D
Center Biology Natural Systems, Washington Univ., Box 1126, St. Louis, MO, 63130
Nutr Cancer; 1(2):8-12 1979

Ethnicity, water supply, socioeconomic status, and urbanization were examined as possible stomach cancer factors among all 174 counties of Minnesota, Wisconsin, and upper Michigan. Multiple regression analysis was used. The proportion of residents born in pattern of stomach cancer mortality in Minessota, Wisconsin, and upper these counties. The settling patterns of Finns, and to a lesser extent of Poles, Norwegians, Danes, and Swedes, are strongly associated with county stomach cancer rates. Socioeconomic status and water supply are less significant. Even after socioeconomic status and water supply are factored out, estimated stomach cancer mortality for these populations is still disproportionately high. Other researchers have identified diet as a major risk factor in stomach cancer and as the prime cause of the ethnicity-stomach cancer association. It is suggested that the natives shared the stomach cancer risk, perhaps by adopting the "high-risk" diet of the foreign-born. (22 Refs)

66. A REVIEW OF POSSIBLE EFFECTS OF SOIL, WATER AND METEOROLOGICAL FACTORS ON CANCER.

Tromp SW
International Society of Biometeorology, Jan Steenlaan 3, Oegstgeest, Leiden, Netherlands
Med Biol Environ; 4(1):66-74 1976

Epidemiological data concerning the effects of soil, water supply, and weather on cancer incidence are summarized. Soil factors include the location of living quarters, soil types, trace elements, and geophysical fields (in particular, low-resistivity zones in soil). Two studies relevant to the effects of water supply are discussed: (1) a study in Greater London in 1947, demonstrating different incidences of all cancers and stomach cancer in regions supplied by wells or by river; (2) a Dutch study in 1953, demonstrating a higher overall cancer mortality in municipalities without a water system compared to those with a system (mortalities of 606 vs 543/100,000). The influence of the chemical composition of drinking water is mentioned. Weather factors include thermal and seasonal effects, the effects of high altitudes, pollution, the indirect effect of meteorological factors on oncogenic viruses, and physiological changes in the body due to meteorological stresses. (96 Refs)

B. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Fluorides

67. FLUORIDATION AND CANCER MORTALITY. (PP. 357-366)

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Incidence of Cancer in Humans, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4, Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 602 pp., 1977.

Cancer death rates in 10 large cities with fluoridated water supplies were compared with those in 10 large cities without fluoridated water supplies. Cities with fluoridated water had about 25/100,000 more cancer deaths than the nonfluoridated cities. In further studies, the rates in additional cities with fluoridated water supplies were compared. The rates in the fluoridated cites were higher only for a particular set of cities, and the higher rates in these cities were present prior to fluoridation. However, the available evidence could not rule out the possibility of fluoridation causing a 1.5% increase in total cancer rates or a 15% increase in specific cancer rates. (19 Refs)

68. CANCER INCIDENCE IN RELATION TO FLUORIDE LEVEL IN WATER SUPPLIES.

Kinlen L
Dep. Regius Professor Med., Oxford Univ., England
Br Dent J; 138(6):221-224 1975

The incidence of thyroid, kidney, stomach, esophagus, colon, rectum, bladder, bone, and breast cancers in areas of England and Wales with high fluoride levels in the water (natural and artificial) was compared with that in control areas having low fluoride levels. Cancer registration data from fluoridated and control areas of the U.S.A, Holland, and New Zealand were also examined. Information on fluoride levels in water was obtained from the water board of each local district. Data from districts with high fluoride levels (greater than or equal to 1 ppm) was matched with a nearby district, similar in size, with low fluoride level (less than or equal to 0.2 ppm). No relation was found between fluoride levels and cancer incidence; the incidence of cancer of any organ was no greater in water with high fluoride content than in control areas.

69. MORTALITY IN SELECTED CITIES WITH FLUORIDATED AND NON-FLUORIDATED WATER SUPPLIES.

Erickson JD
Chronic Diseases Div., Bureau Epidemiology, Center for Disease Control, Atlanta, GA, 30333
N Engl J Med; 298(20):1112-1116 1978

Mortality rates (for blacks and whites only) between 1969 and 1971 were analyzed in 24 cities with fluoridated water (F; total population 15,972,817) and in 22 cities with non-fluoridated water (non-F; total population 11,106,746). During this period 570,671 blacks and whites died in the F cities (crude death rate 1,190.0 per 100,000 person-years), and 351,053 died in the non-F cities,(crude death rate 1,053.6 per 100,000 person-years). Crude death rates from cancer were 206.6 and 183.0, respectively. Adjustment of death rates for age, sex, and race reduced the differential for most causes, changing the death rate to 1,156.0 in F cities and 1102.4 in non-F cities, and the cancer death rates to 199.9 and 192.3, respectively. Analyses of covariance removed the mortality excesses in the F cities, resulting in a death rate of 1,123.9 in F cities and 1,137.1 in non-F cities. The death rates from cancer changed in the same manner (195.3 and 196.9, respectively). This study shows that the marked differences in the crude death rates of F and non-F cities were not caused by fluoridation, and that there is no evidence of a harmful effect, including cancer, attributable to fluoridation. (17 Refs)

70. FLUORIDATED DRINKING WATER AND THE OCCURRENCE OF CANCER.

Hoover RN, McKay FW, Fraumeni JF
Environmental Epidemiology Branch, National Cancer Institute, Bethesda, Md. 20014
J Natl Cancer Inst; 57(4):757-768 1976

A recent report by the National Health Federation, a private agency, related cancer mortality patterns in the United States to fluoridation of water supplies, triggering much public health concern and some political response. To clarify the issues raised, we studied cancer mortality and incidence statistics for US counties, 1950-69. No trends could be ascribed to the consumption of water that is artificially or naturally fluoridated. (Author Abstract)

71. FLUORIDATION OF WATER SUPPLIES AND CANCER - A POSSIBLE ASSOCIATION?

Oldham PD, Newell DJ

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J R Stat Soc Ser C; 26(2):125-135 1977

Data from a recent study of the crude cancer mortality rates in 10 US cities with fluoridated water supplies and 10 US cities with nonfluoridated water were reexamined to determine whether the conclusion that nationwide fluoridation would lead to excess cancer deaths was justified. At the beginning of the study (1950), the cities with fluoridated water had fewer elderly white men and women, more nonwhites aged less than 50 yr, and a greater proportion of cancer deaths than those with nonfluoridated water. At the end of the study, the cities with fluoridated water had many more nonwhites of all ages and fewer whites aged less than 55 yr than those with nonfluoridated water. Taking these variables into account, the excess cancer rate increased by 1% over the study period in the cities with fluoridated water and by 4% in those with nonfluoridated water. In absolute terms, the excess cancer rate between 1950 and 1970 increased by 8.8/100,000 in those with nonfluoridated water. It is concluded that the study provided no evidence that fluoride increases cancer mortality. (7 Refs)

C. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Trihalomethanes and Chlorination By-Products

72. A CASE CONTROL STUDY OF GASTROINTESTINAL AND URINARY TRACT CANCER MORTALITY AND DRINKING WATER CHLORINATION.

Alavanja M, Goldstein I, Susser M

Sch. Health Sciences, Hunter Coll., New York, NY, 10029

Water Chlorination; 2:395-409 1978

To assess the potential cancer hazard associated with drinking chlorinated water, a case-control study was made of 3,446 people who died from gastrointestinal (GI) or urinary tract (UT) cancer in seven New York counties between 1968 and 1970 and 3,444 individually matched controls. There was a statistically significant excess of GI and UT cancer deaths among women living in urban areas of Erie County and among men living in urban areas of Erie and Rensselaer counties. Similar, but nonsignificant, trends were demonstrated for Schenectady and Allegany counties. GI and UT cancer deaths were significantly elevated among men and women in the chlorinated water areas of Erie and Schenectady counties and among men in the chlorinated water areas of Rensselaer county. Residents of Cattaraugus, Chautauqua, and St. Lawrence counties showed no excess GI or UT cancer mortality associated with living in urban or chlorinated water areas. Urban, but not rural, chlorinated water areas showed significantly increased mortality from lung cancer compared with nonchlorinated water areas. No correlation between GI and UT cancer mortality and inorganic ion concentrations was demonstrated. Voluntary reduction of the chloroform concentrations in potable water to less than 100 ug/liter is highly desirable. (7 Refs)

73. EPIDEMIC PROBLEMS AND CHLORINATION OF DRINKING WATER AND SEWAGE IN THE FEDERAL REPUBLIC OF GERMANY.

Muller G

Inst. Water, Soil and Air Hygiene, Federal Health Office, Berlin, W. Germany

Water Chlorination; 2:483-492 1978

Within the last 40 yr, there has been an approx 60% increase in all cancer-related deaths in West Germany. However, gastrointestinal and stomach cancers, the main types that might be induced by drinking water containing chlorinated organic compounds, have decreased. Statistics for regions using unchlorinated and slightly chlorinated drinking water showed the same trend as that found for the entire country. Thus, there is no evidence that chlorination of drinking water promotes cancer. (8 Refs)

74. ASSOCIATION BETWEEN CHLOROFORM LEVELS IN FINISHED DRINKING WATER SUPPLIES AND VARIOUS SITE-SPECIFIC CANCER MORTALITY RATES.

Hogan MD, Chi PY, Hoel DG, Mitchell TJ

Biometry Branch, Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC, 27709

J Environ Pathol Toxicol; 2(3):873-887 1979

Statistical and biological problems of the indirect approach to assessment of the impact of environmental agents on public health are illustrated using the potential association between various site-specific cancer mortality rates and chloroform (CF) levels in finished drinking water supplies. Both unweighted and weighted regression procedures were used to determine to what extent (if any) the results might depend on the weighting scheme adopted. CF exposure data were collected in 1975, but the cancer mortality rates with which they were being associated were for 1950-1969. Given the long cancer latent period, the most relevant exposure data would be those from 1925-1959. Even if the available exposure measurements were consistent over long periods of time, the CF readings might still not be representative of the exposure history of the total population at risk. One of the most significant factors affecting the results of any general linear regression analysis is selection of the explanatory variables. In this study, the issue of cancer latency period was ignored, and data were lacking on certain risk factors, such as cigarette smoking. Within these restrictions, there was some correlation between CF levels in finished drinking water supplies and cancer mortality for specific sites such as the bladder and rectum-intestine. Associations such as these, however, may not be very meaningful and need to be interpreted with great care. (13 Refs)

75. ASSOCIATION OF CANCER MORTALITY RATES AND TRIHALOMETHANE LEVELS IN MUNICIPAL DRINKING WATER SUPPLIES (MEETING ABSTRACT).

Cantor KP, Hoover R, Mason T, McCabe LJ

NCI, Bethesda, MD 20014

Am J Epidemiol; 106(3):230-231 1977

Associations between site- and sex-specific county cancer mortality rates in whites and levels of trihalomethanes in drinking water were investigated using a multiple regression approach. Data from two 1975 EPA surveys of municipal water supplies served as exposure indices and their association with subsequent surveys was examined. Counties were stratified in several ways for the analysis, including percent of county population served by the sampled supply, and region of the country. Positive associations were observed for several site-sex combinations including bladder, brain, lung, and colon in both sexes, and non-Hodgkin's lymphoma and kidney in males. Stomach cancer in females showed a negative association. The strength of association for stomach, colon, and lung cancer depended upon the specific predictor variables in the regression model. Bladder cancer mortality rates showed the most consistent association with a trihalomethane index, and the association persisted when rates were corrected for the presence of high-risk industries. (Author abstract) (no Refs)

76. ASSOCIATIONS OF CANCER MORTALITY WITH HALOMETHANES IN DRINKING WATER.

Cantor KP, Hoover R, Mason TJ, McCabe LJ

Health Effects Res. Lab., U.S. Environmental Protection Agency, Cincinnati, OH, 45268

J Natl Cancer Inst; 61(4):979-985 1978

Age-standardized cancer mortality rates by site and sex for whites in 76 US counties were compared with levels of chloroform, bromine-containing trihalomethane(s) (BTHM), and total trihalomethane(s) (THM) in the drinking water. The 76 counties are greater than 50% urban, and over half the population is served by a sampled water supply. Using several demographic, socioeconomic, and industrial variables, a predicted mortality rate was computed and compared with the actual rate. The resulting residual mortality rate for each county was compared with the level of one of the three THM indicators by use of the bivariate correlation coefficient. Counties were grouped according to the overall percentage of the county served by the sampled water supply (low, intermediate, or high) and by geographic location. Bladder cancer residual mortality in both sexes showed a strong correlation with BTHM. This correlation persisted in spite of controls for social class, ethnic group, urban vs rural residence, pres nce of specific high-risk industries, and lung cancer rates (possible surrogate for levels of cigarette smoking). Brain cancer was also correlated in both sexes, but the associations were not as strong, and there was regional variation. Other sites that gave indications of an association were: CHCl3 levels and male kidney cancer, BTHM and female lung cancer, and THM levels and non-Hodgkin's lymphoma in men. Stomach cancer in women showed a negative correlation. (23 Refs)

D. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Asbestos and Other Particulates

77. AN INVESTIGATION OF THE USE OF ASBESTOS CEMENT PIPE FOR PUBLIC WATER SUPPLY AND THE INCIDENCE OF GASTROINTESTINAL CANCER IN CONNECTICUT, 1935-1973.

Harrington JM, Craun GF, Meigs JW, Landrigan PJ, Flannery JT, Woodhull RS

Environmental Hazards Activity, Chronic Diseases Div., Bureau Epidemiology, Center Disease Control, Atlanta, GA, 30333

Am J Epidemiol; 107(2):96-103 1978

Determination was made of the effects of the use of asbestos cement pipe for public water supply on the incidence of stomach, colon, and rectal cancer in Connecticut between 1935 and 1973. Tumor incidence per township was obtained from the Connecticut Tumor Registry. For all towns, the date(s) of installation of the asbestos cement pipe, the length of this type of pipe compared to other types, and the population serviced by the pipe were determined. These factors were incorporated into two composite indices: the Assessment of Exposure and Risk Factors. Observed to expected (O/E) ratios of all three types of cancer tended to increase as the population density increased. Furthermore, O/E ratios for colon and rectal cancer were opposite those for stomach cancer. However, there was no pattern of association between cancer incidence and the use of asbestos cement pipe. (26 Refs)

78. INVESTIGATING POSSIBLE EFFECTS OF ASBESTOS IN CITY WATER: SURVEILLANCE OF GASTROINTESTINAL CANCER INCIDENCE IN DULUTH, MINNESOTA.

Levy BS, Sigurdson E, Mandel J, Laudon E, Pearson J

Minnesota Dept. Health, Minneapolis, MN 55440

Am J Epidemiol; 03(4):362-368 1976

The recent discovery of from 1 to 30 million amphibole asbestiform fibers per liter of Duluth tap water and data suggesting a link between occupational exposure to asbestos fibers in the air and gastrointestinal (GI) cancers prompted this study. GI cancer incidence data for 1969-1971 were gathered and compared with similar data for residents of Minneapolis and St. Paul. Incidence rates were also obtained for Duluth residents during 1972. The data were adjusted according to age and sex. There were some differences in the number and type of GI cancers among all three cities, but none of these was statistically significant. There was also no notable increase in total GI cancers among Duluth residents from 1969-1972. Further cancer incidence studies are planned to quantitate the ingestion and inhalation of asbestos by residents of Duluth and comparison cities. (15 refs)

79. CANCER MORTALITY IN RELATION TO ASBESTOS IN MUNICIPAL WATER SUPPLIES.

Wigle DT

Bureau Epidemiology, L.C.D.C., Health and Welfare Canada, Tunney's Pasture, Ottawa, Ontario, K1A 0L2, Canada

Arch Environ Health; 32(4):185-190 1977

Cancer mortality in 22 communities in Quebec grouped by type of exposure to asbestos fibers in water supplies (high, possible high, and probable low exposures) was evaluated. The expected numbers of cancer deaths were calculated by applying the Quebec age-specific (5-yr groups), sex-specific, site-specific, and period-specific (1965-1967, 1970-1972) mortality rates to the 1966 or 1971 census populations by age and sex for each community. The results were compared with the actual number of deaths. Excess mortality due to cancer of the stomach (men), pancreas (women), and lung (men) was observed in the two communities with known high exposure. The excess stomach and lung cancers among men may reflect occupational exposure to asbestos. This study does not support an association between pancreatic cancer and exposure to asbestos fibers in drinking water, because there was no excess among men. A relationship between stomach cancer and waterborne asbestos likewise is not supported by these results, because of the absence of an excess among women. (11 Refs)

E. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Nitrites, Nitrates, and Nitrosamines

80. NITRATE NITROGEN LEVELS IN DRINKING WATER OF URBAN AREAS WITH HIGH- AND LOW-RISK POPULATIONS FOR STOMACH CANCER: AN ENVIRONMENTAL EPIDEMIOLOGY STUDY.

Zaldivar R, Wetterstrand WH

International Res. Group Cancer Epidemiology Human Ecology, 5055 N.W. 7th St. Suite 606, Miami, FL, 33126

Z Krebsforsch; 92(3):227-234 1978

A correlation study between mean nitrate levels (ppm) in drinking water samples (total 1,389) of Chilean urban areas and age-adjusted death rates per 100,000 population from stomach cancer, by province or region and sex, was made. Drinking water samples from all provinces had a weighed mean of 1,446 ppm, with a range of 0.00-30.00 ppm. Nitrate levels showed a positive but not significant association with male death rates. The correlation coefficient was +0.0335.

Similarly, the levels exhibited a positive but not significant correlation with female death rates (r = +0.0486). When nitrate levels and male (r = 0.1367) or female (r = +0.1143) death rates were studied by region, positive but insignificant correlations were detected. Using Cochran's approximation, mean nitrate levels in drinking water samples from six provinces with 50% of the Chilean population a decreased from 1,835 in 1953-1955 to 1,291 ppm in 1973-1975, but there was no significant difference (t = 1.32) between the two values, except in samples from Santiago Province (t = 2.11, P less than 0.05). Provinces (south central area) with the highest gastric cancer mortality rates in the world for women (up to 40.8/100,000), and ranking second for men (up to 84.1/100,000), exhibited a low mean level (0.825 ppm). (25 Refs)

81. NITRATE IN WATER SUPPLIES.

Geleperin A, Moses VJ, Fox G
Sch. Public Health, Univ. Illinois, Chicago, IL
Ill Med J; 149(3):251-253 1976

A model study was conducted in ten English cities to determine the possible carcinogenic effects of nitrates in the water supply. One community had high nitrate concentrations (90 mg/liter) and the other nine served as controls. The one high nitrate community and one control had significantly higher percentages of stomach cancer (26% and 27%) than the remaining eight communities. The ratio of observed to expected deaths was 1.31 in men and 1.93 in women. The respective values were 0.95 and 1.00 for bladder cancer. A similar study was conducted in three Illinois communities that had, respectively, insignificant nitrate, 40-45 ppm nitrate, and high nitrate water concentrations. The proportional mortality rates by cancer location for three age groups in the three communities showed no significant differences among the localities. Over an eight year period between 1959 and 1966, no significant differences were found among the three localities in mortality rate.

F. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Arsenic

82. RELATIVE INCIDENCE OF SKIN CANCER IN CHINESE IN TAIWAN: WITH SPECIAL REFERENCE TO ARSENICAL CANCER.

Yeh S
Dept. Path., Nat. Taiwan U. Coll. Med., Taipei, China
Natl Cancer Inst Monogr; 10:81-107 1963

Of the 12,084 malignant tumors found among 100,554 surgical specimens, 563 (4.65%) were skin tumors (282 carcinomas of skin, and 281 sarcomas, malignant melanomas, and carcinomas of lip, penis and vulva). Of the 489 carcinomas listed, 385 were epidermoid, 58 basal-cell, 35 intraepidermal (Bowen's disease), 8 adenocarcinomas and 3 carcinosarcomas. A study of 4000 autopsies included 570 (14.25%) malignant tumors, of which 13 were skin carcinomas or anatomically related malignancies. The skin cancer incidence reported (1.02%) is much lower than any necropsy data from the USA. While most numerous in the 6th decade, skin cancers increased steadily (proportionally) up to age 80. Carcinoma of the penis, constituted 0.84% of all tumors (2.2% of all cancers in males), and 100/101 were epidermoid, a majority occurring in men over 40. The authors suggest that phimosis and bad personal hygiene may be etiological factors in penile cancer. Malignant melanomas (44) were found in 0.08% of all autopsies (0.52% of all tumors). Arsenical skin cancers were found in 52 patients (32 males, 20 females) of a population of approximately 160,000, who lived in a limited area where the arsenic content of the drinking water is 0.8 to 2.5 ppm; 73.1% occurred at ages over 50. Skin lesions were seen in 81.8% of patients with blackfoot (which appeared to be closely associated with chronic arsenical intoxication); 8% had carcinoma. From a study of 94 exposed for varying periods of time, hyperpigmentation was found only in persons exposed at least 5 yr, keratinism 15 yr, cancer 20 yr. Some patients developed cancer 30 to 40 yr after the use of the contaminated water was discontinued.

83. SKIN CANCER AND WATER ARSENIC IN LANE COUNTY, OREGON.

Morton W, Starr G, Phol D, Stoner J, Wagner S, Weswig P
Univ. Oregon Medical Sch., Portland, OR 97201
Cancer; 37(5):2523-2532 1976

An attempt was made to correlate the incidence of skin cancer with known high levels of arsenic in the water supplies in Lane County, Oregon. Incidence rates were based on all histopathologically confirmed cases among Lane County residents diagnosed during 1958-1971 and were compared to mean water arsenic levels measured during 1968-1974. Skin cancer cases based solely on clinical diagnosis were excluded from the study. Basal cell carcinoma had a mean annual incidence rate of 88/100,000, a 5:4 M:F sex ratio, and an increasing risk for both sexes in urban areas. Squamous cell carcinoma incidence was 50/100,000 and showed 2:1 M:F sex ratio but no urban predilection. Neither type of skin cancer was directly related to the arsenic levels as expected, although sporadic individuals with sufficient exposure could manifest the relationship. Fewer than expected drinking water sources contained high arsenic content, so the Lane County data do not necessarily contradict previous reports of positive correlation. The basal cell carcinoma pattern suggested that this disease might be potentiated by urban air pollutants.

G. Epidemiological Associations of Contaminants of Water Supplies with Human Cancers: Trace Metals

84. CORRELATIONS BETWEEN CARCINOGENIC TRACE METALS IN WATER SUPPLIES AND CANCER MORTALITY.

Berg JW, Burbank F
Natl. Cancer Inst., Bethesda, Md.
Ann NY Acad Sci; 199:249-264 1972

The product of the frequency of detection of trace metals in drinking water systems and the average detected metal concentration was determined for ten basin areas in the United States. Areas were ranked according to the size of this statistic and the rank order was compared with the rank order of the areas for mortality from 34 types of cancer. Positive correlations between trace metals in drinking water and cancer mortality were found in 28 cases, eight more than expected. The excess of positive correlations came mainly from cadmium (correlated with oral and pharyngeal cancer, esophageal cancer, breast cancer, intestinal cancer) and lead (correlated with intestinal cancer, kidney cancer, ovarian cancer, all leukemias). For chromium, cobalt and iron there were no positive correlations significant at the 5% level.

85. CORRELATION BETWEEN CANCER MORTALITY AND METALLIC ION CONTENT OF CITY DRINKING WATER.

Granata A, De Angelis L, Piscaglia M, Frago G
U. Messina Inst. Occup. Med., Italy
Minerva Med; 61(36):1941-1950 1970

Total metallic ion content (iron, magnesium, aluminum, manganese, nickel, lead, copper, zinc, chromium, cadmium

and tin, in g/liter) in drinking water of the 14 districts of Pesaro, Italy was measured twice daily and the total mean conc compared with the cancer mortality classified at 4 levels (high, mean for the commune, below mean and very low). All water samples had iron, magnesium and aluminum; manganese was found occasionally. At group levels, a significant correlation was found between total ion conc and cancer mortality, as well as with mortality due to cancer of the G.I. tract, liver and pancreas. The mean total ion value for the lowest value districts was 9.96 g/liter (spring water) as compared to 30.98 g/liter (well water) for high-value districts.

III. CLINICAL ASSOCIATIONS OF CONTAMINANTS OF WATER SUPPLIES WITH HUMAN DISEASES

A. Clinical Associations of Contaminants of Water Supplies with Human Diseases: Nitrites, Nitrates, and Nitrosamines

86. NITRATES AND GASTRIC CARCINOMA.

Thaler H
4. Medizinische Abteilung, Wilhelminenspital, Montlearstr. 37, A-1171 Vienna, Austria
Dtsch Med Wochenschr; 101(47):1740-1742 1976

General discussions are presented on the increased incidence of gastric cancer in Japan and Chile and the possible hazards of long-term isosorbide dinitrate treatment of patients with coronary insufficiency. In Japan, the high gastric cancer incidence is due to the regular consumption of vegetables with a high nitrite and nitrate content and of fish, which is a source of secondary amines. Nitrites and secondary and tertiary amines react in the stomach to form carcinogenic nitrosamines. In Chile, the high incidence of gastric cancer is due to the intense use of nitrate fertilizers, which are reduced to nitrites by microorganisms. The nitrites are taken up from the drinking water and plants. Nitrosamines are synthesized from these nitrites and amines in the stomach. The long-term use of isosorbide dinitrate does not appear to increase cancer risk, because achlorhydria would be required for reduction of the nitrate to nitrite in the gastric juice, but the synthesis of nitrosamines from these nitrites would require normal gastric juice. Consequently, nitrate reduction and nitrosamine synthesis in the gastric juice mutually preclude each other. (8 Refs)

87. GASTRIC CANCER IN COLOMBIA. I. CANCER RISK AND SUSPECT ENVIRONMENTAL AGENTS.

Cuello C, Correa P, Haenszel W, Gordillo G, Brown C, Archer M, Tannenbaum S
Div Health, Univ Valle, Cali, Colombia
J Natl Cancer Inst; 57(5):1015-1020 1976

A case-control study of patients discharged from hospitals revealed fourfold differences in geographic variation in stomach cancer risk within the Department of Narino (Colombia). Data from gastroscopic surveys of population groups, samples of water supplies, and urine and saliva in Narino also indicated a generally positive correlation among the following parameters: 1) gastric cancer risk, 2) prevalence of chronic atrophic gastritis and intestinal metaplasia, 3) nitrate content of well waters, and 4) nitrate excretion by the population. Urinary excretion reflected the ingestion of nitrates, and this implied a higher average intake of nitrates in the populations at high risk for stomach cancer. The Narino data could be construed as presumptive epidemiologic evidence for the role of nitrate availability in the etiology of stomach cancer. (Author Abstract)

88. NITRATE AND THE ETIOLOGY OF GASTRIC CANCER. (PP. 1609-1625)

Tannenbaum SR, Archer MC, Wishnok JS, Correa P, Cuello C, Haenszel W
Dept. Nutrition and Food Science, Massachusetts Inst. Technology, Cambridge, MA, 02139
Human Risk Assessment, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4 (Book C), Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 583 pp., 1977.

Two models of gastric cancer are proposed based on evidence gathered in Colombia, South America, and laboratory tests of these models are described. A survey of water supplies in a high-risk area in Colombia has shown high concentrations of nitrates in wells. In this region, the disease progresses from normal mucosa to superficial gastritis, chronic atrophic gastritis, gastritis with intestinal metaplasia, and, finally, gastric cancer. By age 25, greater than 75% of the population in the high-risk area suffers from gastritis, whereas in the low-risk area the population appears to be free of gastric pathology. Two models emerge from these observations: (1) an agent in the environment, possibly an N-nitroso compound, leads to gastritis, which naturally progresses to intestinal metaplasia and then to cancer; (2) gastritis leads to elevation of the stomach pH and, concomitantly, to establishment of a microbial flora capable of nitrate reduction. This process, in turn, leads to a steady formation of carcinogenic N-nitroso compounds, which leads to gastric cancer. At present, there is not enough evidence to decide between these two models. Laboratory studies involving saliva and stomach acid indicate that bacteria in the stomach of an individual with gastritis or intestinal metaplasia play the dual roles of nitrite former and nitrosation catalyst. Other studies have disclosed the formation of cyanamides from primary and secondary amines in human saliva. Mixing of these compounds with the stomach contents would result in the formation of highly mutagenic and carcinogenic N-nitrosocyanamides. (46 Refs)

89. THE CANCER REGISTRY OF CALI COLOMBIA - EPIDEMIOLOGIC STUDIES OF GASTRIC CANCER.

Correa P, Bolanos O, Garcia FT, Gordillo G, Duque E, Cuello C
No affiliation
Recent Results Cancer Res; 50:155-169 1975

The general operation of the registry, and work done in the area of gastrointestinal tumors were described. The data reported were obtained from the city of Cali, which has four well demarcated boundaries; the 1964 national census sets the population at 638,211. Employing medical students in interviewing and data collection, the studies began with the registry findings and progressed to other special clinical, pathologic, and field studies. Figures indicate the incidence rate of gastric cancer in Cali males was 57.5 per 100,000, second only to Japan. Further analysis of the figures considered place of birth and population of origin. Available histologic material was reviewed and classified by the system of Jarvi and Lauren, and indicated an excess of all histologic types for the immigrants from the rural high-altitude South, especially of the intestinal type. In attempting to link incidence data with the prevalence of lesions (potential cancer precursors) gastric specimens were obtained and special attention was given to intestinal metaplasia of the gastric

mucosa. Prevalence figures for each migrant group were determined, and a clear gradient was observed indicating areas representing the extremes of gastric cancer risk. In-depth studies of such areas aimed at the identification of factors associated with intestinal metaplasia or other precancerous conditions, were undertaken by examining populations with drastically different prevalence rates. In addition to a special questionnaire, biochemical tests, gastroacidogram, gastroscopy and gastric biopsy were employed. Symptoms showing the greatest discrimination between the two populations included sensations of "fullness" in the epigastric area, vomiting, nausea, pyrosis, and pain; likewise, a greater prevalence of lesions was found in the high-risk area, while biochemical tests lacked any discrimination. Limited environmental studies indicated that in areas of highest risk, the water supplies have a high nitrate content, most especially in dug-wells and subterraneous fountains. Cancer registration should be encouraged in developing countries, not only to provide information about the local situation, but also to study trends in other countries; cancer incidence in western countries may contrast with incidence in developing countries.

B. Clinical Associations of Contaminants of Water Supplies with Human Diseases: Arsenic

90. SKIN CANCER IN CHRONIC ARSENICALISM.

Yeh S
Coll. Med., Natl. Taiwan U., Taipei, Taiwan
Hum Pathol; 4(4):469-485 1973

The prevalence of skin cancer, hyperpigmentation, keratosis, and blackfoot disease (a peripheral vascular disorder resulting in gangrene of the extremities) among 40,421 residents of a small area of Taiwan where artesian well water with a high arsenic concentration is used was studied. The prevalence rates for these disorders were 1.6%, 18.3%, 7.1%, and 0.89%, resp. The male-to-female ratio was 2.91 for skin cancer, 1.1:1 for hyperpigmentation and keratosis, and 1.99:1 for blackfoot disease; the prevalence of all four increased with age. A total of 303 arsenical cancers in 184 patients were studied histologically; 78% of the patients were 50 yr and older. Of these lesions, 57 were epidermoid carcinoma, 45 were basal cell carcinoma (28 deep and 17 superficial), 176 were intraepidermal carcinoma (23 type B keratosis and 153 classic Bowen lesions and variants), and 25 were combined forms. Bowen's variants included ten with squamous whirls, seven with features of seborrheic keratosis, and 12 with horn formation. Ten of the basal cell carcinomas revealed bizarre multinucleated giant cells and nuclear atypicalities. Among 81 benign type A arsenical keratoses, 57 revealed no cellular atypy and 24 revealed mild changes. The fine structure in 30 classic cases of Bowen's lesion is described and illustrated. A 5-yr follow-up study of 422 skin cancer patients and 344 patients with blackfoot disease included analysis of mortality ratios and causes of death.

91. EFFECTS AND DOSE-RESPONSE RELATIONSHIPS OF SKIN CANCER AND BLACKFOOT DISEASE WITH ARSENIC.

Tseng WP
Dept. Medicine, Natl. Taiwan Univ., Coll. Medicine, Taipei, Taiwan, Republic of China
Environ Health Perspect; 19:109-119 1977

A general survey of 40,421 inhabitants of a limited area of Taiwan where artesian well water had a high concentration of arsenic is presented. A high percentage of the population suffered from chronic arseniasis, and a considerable number had arsenical skin cancer and/or blackfoot disease (a peripheral vascular disorder resulting in gangrene of the extremities, especially the feet). The epidemiological, clinical, and pathological aspects of both diseases were studied. Of the total population, 428 (10.6/1000) had arsenical skin cancer, all of whom were over 20-yr-old. A rate of 9/1000 were found to have blackfoot disease and 1.5/1000 had both skin cancer and blackfoot disease (the expected rate is 0.9/1000). The prevalence of skin cancer, hyperpigmentation and keratosis increased steadily with age. A 5 yr exposure to arsenic in the water was necessary for hyperpigmentation to occur, 14 yr for keratosis, and 24 yr for cancer. A dose-response relationship between blackfoot disease and the arsenic level in the drinking water was found and was similar to that for cancer. Since the use of the wells was halted in 1956, no new cases of blackfoot disease have been reported. Skin cancer and blackfoot disease are both part of the entity of chronic arseniasis. (27 Refs)

92. A SURVEY OF A POPULATION EXPOSED TO HIGH CONCENTRATIONS OF ARSENIC IN WELL WATER IN FAIRBANKS, ALASKA.

Harrington JM, Middaugh JP, Morse DL, Housworth J
Center Disease Control, Atlanta, GA, 30333
Am J Epidemiol; 108(5):377-385 1978

An epidemiologic study of 211 persons exposed to high arsenic concentrations (up to 10,000 ug/l) in their well water was carried out to assess exposure, absorption, and clinical sequelae of chronic arsenic ingestion. In well-water drinkers, close correlations were found between well water arsenic levels and urinary arsenic and between well water arsenic levels and hair arsenic levels. Nail arsenic levels correlated poorly with water arsenic exposure. No clinical or hematologic abnormalities were found. (23 Refs)

93. ARSENIC CONTAMINATION OF DRINKING WATER AND FOODSTUFFS CAUSING ENDEMIC CHRONIC POISONING.

Zaldivar R
Regional Hospital, Antofagasta, Chile
Beitr Pathol; 151(4):384-400 1974

Numerous studies in both hemispheres have documented the co-occurrence of arsenic in drinking water and pre-cancerous and squamous cell skin lesions. Epidemiological data from Antofagasta, Chile, showed a 7-fold decrease of arsenic over a 3 yr period and an even more dramatic reduction in reported cutaneous lesions in a sample of 437 patients following filtration of drinking water. Major delayed effects of chronic arsenic poisoning include pre-cancerous lesions of palms and soles and skin not exposed to sunlight, as well as liver, lung, and possible bladder, larynx, mouth, and esophageal carcinomas. Death however may result from vascular occlusion and thrombosis; arsenic poisoning may be an important factor in the high incidence of myocardial infarction of children and young adults in the population at risk. Tables summarizing the data include differential mortality figures, yearly arsenic conc figures, age and sex distributions.

94. ENVIRONMENTAL AND CLINICAL INVESTIGATIONS ON ENDEMIC CHRONIC ARSENIC POISONING IN INFANTS AND CHILDREN.

Zaldivar R, Guillier A
5055 N. W. Seventh Street, Suite 606, Miami, FL 33126
Zentralbl Bakteriol Orig B; 165(2):226-234 1977

The diagnosis of chronic arsenic poisoning in 337 infants and children exposed to arsenic-polluted drinking water was based on symptomatology, laboratory analyses of arsenic

content in hair, nails, and urine, and morbid anatomy and histopathology of biopsy and autopsy specimens. Of 337 children with chronic arsenic dermatosis, 5 died from severe chronic poison lesions. In the first yr of the life of these children, the mean arsenic dose was 0.130 mg/kg body wt/day. Persons between the ages of 81-90 yr had a mean arsenic dose of 0.002 mg/kg body wt/day. Autopsy results on 3 children and an 18-yr-old man indicated fibrous thickening of the arteries. Severe luminal obliteration was also evident. A 2-yr-10-mo-old boy had a hypertrophic heart with an infarction at the apex of the left ventricle. In a survey of 100 children with chronic arsenic dermatosis, 19 exhibited Raynaud's phenomenon. In 15/19, vasospasms of the digital arteries were observed and associated with pain; in 4 cases ischemia of the tongue was observed. It was suggested that the maximal allowable arsenic level in drinking water should be 0.01 ppm. (20 Refs)

95. ARSENIC IN THE DRINKING WATER OF THE CITY OF ANTOFAGASTA: EPIDEMIOLOGICAL AND CLINICAL STUDY BEFORE AND AFTER THE INSTALLATION OF A TREATMENT PLANT.

Borgono JM, Vicent P, Venturino H, Infante A
Servicio Nacional de Salud, Ministerio de Salud Publica, Republica de Chile, Santiago, Chile
Environ Health Perspect; 19:103-105 1977

Arseniasis in the city of Antofagasta, Chile, 6 yr after a water treatment plant began operation to reduce the amount of arsenic in the water supply, is examined. A clinical and epidemiological approach was used for the determinations of arsenic content in hair and nail clippings of the general population and in school children 6 yr old or less. Clinical examination of the children determined the presence or absence of cutaneous lesions attributable to arseniasis. Cutaneous lesions were not found in school children younger than 6 yr. Their exposure time may not have been long enough to develop them, or the arsenic content is under the necessary level to produce clinical manifestations. The 1976 values of arsenic levels above normal values in hair was 40.1% as opposed to 82.6% in 1968 and 1970. A similar decline in mean value for abnormal arsenic content in nail clippings was observed. Mean values of arsenic content in carbonated beverages dropped from 0.24 mg/liter in 1968 to 0.06 mg/liter in 1976. Contamination still persists, but at significantly lower levels, and continued surveillance is suggested. (no Refs)

C. Clinical Associations of Contaminants of Water Supplies with Human Diseases: Asbestos and Other Particulates

96. AN OUTBREAK OF PLEURAL MESOTHELIOMA AND CHRONIC FIBROSING PLEURISY IN THE VILLAGE OF KARAIN/URGUP IN ANATOLIA.

Baris YI, Sahin AA, Ozesmi M, Kerse I, Ozen E, Kolacan B, Altinors M, Goktepeli A
Dept. Chest Diseases, Hacettepe Univ. Sch. Medicine, Ankara, Turkey
Thorax; 33(2):181-192 1978

The cause of the 11 deaths from pleural mesothelioma and the 5 cases of fibrosing pleurisy that occurred among the 575 inhabitants of Karain, Turkey, in 1975-76 was investigated. In the previous 5 yr, there had been 25 cases of mesothelioma. There was no definite evidence of a genetic factor; the main occupation of those affected was agriculture. Examination of the physical and economic structure of the village and geological, biological, and chemical analyses of the food, rocks, soil, and water indicated the presence of a few asbestos fibers, 5-70 mum long, in the water. Asbestos fibers were also found in the pleural tissues of 2/5 patients examined. Pleural calcification was seen quite frequently, and it was typical of that resulting from asbestos exposure. Inhabitants of neighboring villages were free of mesothelioma. The asbestos fibers may be derived from the wearing down of asbestos-containing rocks by the water supply. They are either ingested or inhaled after the water evaporates and the fibers become airborne. (28 Refs)

97. ENDEMIC NEPHROPATHY AND CANCER OF THE UPPER TRACT UROTHELIUM IN YUGOSLAVIA.

Markovic B
Med. Ctr., Gnjilane, Yugoslavaia
Isr J Med Sci; 8(4):540-548 1972

The epidemiology of endemic nephropathy (EN) and upper urinary tract cancer in Yugoslavia were investigated. EN and its associated cancer are prevalent in rural communities located along the larger Yugoslavian rivers. In some villages, morbidity from EN reaches 9-16%. Polyps, papillocarcinomas and carcinomas have been found in the renal pelvis, ureters and urinary bladder of 33% of autopsy cases of EN in one study. The etiology of EN and related cancers in Yugoslavia appears to be related to land use. Extensive lumbering operations in the Balkans mountains have stripped the mountains of the tree cover. The result has been erosion of the mountain soils and rocks into the rivers of the region. When the rivers flood, silicate particles eroded from the mountains enter public drinking water systems and are ingested. In the blood, these silicates are changed to silicic acid which causes necrotic changes in the renal parenchyma.

98. ASBESTOS BODIES IN LUNG PARENCHYMA IN RELATION TO INGESTION AND INHALATION OF MINERAL FIBERS.

Auerbach O, Hammond EC, Selikoff IJ, Parks VR, Kaslow HD, Garfinkel L
Veterans Admin. Hosp., East Orange, NJ
Environ Res; 14(2):286-304 1977

Lung tissues from 282 Duluth, Minnesota women who died between 1953 and 1973 were examined by light microscopy for the presence of asbestos bodies attributed to the ingestion of water contaminated with fibers from a taconite ore-processing plant in operation since 1955. The women, who had lived in Duluth for at least 15 yr, had never been occupationally exposed to asbestos particles and had not lived in neighborhoods with high levels of asbestos dust. The mean number of asbestos particles in ashed lung specimens from 96 Duluth women exposed to the contaminated drinking water for 17-18 yr was somewhat lower than the number in tissues from 96 age-matched New York City women. Moreover, the percentage of tissues with one or more asbestos bodies was not higher in this group of Duluth women than in tissues from women with no asbestos exposure or exposures of 5-6 or 11-12 yr. Thus, there is no evidence that small asbestos fibers are taken into the bloodstream as a result of drinking Duluth water. In another study, more asbestos particles were found in lung specimens from 19 Patterson, New Jersey men who had lived within one-half mile of an asbestos factory than in specimens from 19 New York City men. (20 Refs)

IV. CARCINOGENICITY AND MUTAGENICITY STUDIES OF WATER CONTAMINANTS IN EXPERIMENTAL SYSTEMS AND AQUATIC ORGANISMS

A. Tumor Induction in Aquatic Organisms by Contaminants of Water: Field and Laboratory Studies

1. Tumor Induction in Aquatic Organisms by Water Contaminants: Field Studies

99. FREQUENCY OF FISH TUMORS FOUND IN A POLLUTED WATERSHED AS COMPARED TO NONPOLLUTED CANADIAN WATERS.

Brown ER, Hazdra JJ, Keith L, Greenspan I, Kwapinski JB

Chicago Med. Sch., Ill.

Cancer Res; 33(2):189-198 1973

Data are presented on the incidence of tumors found in 2121 fish examined from the Fox River watershed (4.38%) as compared to 4639 fish examined in Canada (1.03%). The water systems were compared as to pollution potentials, and the Fox River was found to be a highly polluted system. Among the pollutants found were mercury, lead, arsenic, toluene, crude oil, gasoline, benzanthracene, chlorinated hydrocarbons, phosphates, sulfates, and coliform bacteria. Factors such as dissolved oxygen content, temperature, and nutritional variation were considered similar in both water systems. It is concluded that these pollutants were responsible for the greater frequency of tumors. No attempts were made to determine the effects of pollution on the long term human users of the water or to determine the virus contents of the water system under study. Plans are now being made to study the waters for fish viruses and, incidentally, those enteric viruses that one might expect in a river system that is termed "a floating sewer."

100. CARCINOGENIC SOURCES IN FISH TUMORS FOUND IN THE FOX VALLEY WATER SHED (MEETING ABSTRACT).

Hazdra JJ, Brown ER, Baudendistel J, Arndt T, Keith L

Illinois Benedictine College, Lisle, Illinois 60532

Abstracts Of Papers, Am Chem Soc, 167th Natl Meeting. Baltimore, Md., Port City Press, Inc., 1974.

The search for the source(s) of cancerous tumors found in fish of the Fox Valley Water Shed was the topic studied. Inorganic and organic pollutants were studied. Inorganic residues were measured by atomic absorption spectroscopy. The organic residues were determined via electron-capture gas chromatography. Values were compared with those found in the Canadian Watershed which was the comparative source for the percentage of fish found with tumors. It has been found that 4.38% of the fish in the Fox Valley Water Shed had cancerous tumors as compared with 1.03% present in the Canadian Water Shed. Monthly records of the inorganic compounds trace metals, and organic materials were recorded and these calculated as to possible sources of oncogenic materials capable of producing tumors. Our results have definitely linked certain forms of water pollution with the presence of these tumors and research is being continued to pin-point these causes. (Author Abstract)

101. LYMPHOMA IN ESOX LUCIUS (NORTHERN PIKE): VIRAL AND ENVIRONMENTAL INTERACTIONS.

Brown ER, Sinclair TF, Keith L, Hazdra JJ, Callaghan OH, Inch WR

University of Health Sciences/Chicago Medical School, Chicago, Ill. 60612

Proc Am Assoc Cancer Res; 17:2 1976

Our publications have shown a relationship between chemical pollution of waterways and the frequency of fish tumors. Tumor frequency appears to have a direct relationship to the amount of pollution. Studies in the Chotak Wisconsin lakes, Fox River (Chicago) and Lake of the Woods (Canadian control) indicate that as the pollution increases, particularly in organic chemicals, the frequency of tumors in fish increases and vice versa. Studies on the etiology of the lymphoma in Esox lucius tend to confirm the findings that this is of a virus etiology. Other studies have shown that the route of inoculation, dose size, age and size of the animal, and temperature of the water all are factors in tumor "takes". Laboratory studies have shown that tumors may be produced in fish by chemicals simulating those found as natural water pollutants. Many fish found in the polluted environment contain human enteric viruses in their intestinal tract. They are also a potentia. hazard to individuals who clean and consume these fish. (Author Abstract)

102. ENVIRONMENTAL CARCINOGENESIS STUDIES IN FISHES OF THE GREAT LAKES OF NORTH AMERICA.

Sonstegard RA

Dept. Microbiology, Univ. Guelph, Guelph, Ontario, Canada

Ann NY Acad Sci; 298:261-269 1977

Investigations from 1973-76 of greater than 50,000 Great Lakes fish revealed epizootics of benign gonadal tumors in goldfish, carp and goldfish x carp hybrids. Older male hybrids had tumor frequencies of up to 100% in polluted waters. The frequency of epizootics of white sucker papilloma was increased to 100% in the heavily polluted Burlington Harbor of Lake Ontario. Chemical pollutants in the water may interact with viral and genetic factors to produce these tumors. (38 Refs)

103. CHEMICAL POLLUTANTS IN RELATION TO DISEASES IN FISH.

Brown ER, Sinclair T, Keith L, Beamer P, Hazdra JJ, Nair V, Callaghan O

Dept. Microbiology, The Chicago Medical Sch., 2020 West Ogden Ave., Chicago, IL 60612

Ann NY Acad Sci; 298:535-546 1977

The relationship between water pollution and health hazards in fish in two water systems (pollution-free Canadian "Lake of the Woods" and the polluted Fox River) was investigated. Fish were caught from both rivers and examined for tumors and nononcogenic diseases. The nononcogenic diseases encountered included columnaris disease, hemorrhagic septicemia, Dee disease, black spot disease, saprolegnia, channel catfish virus disease, and lymphocystis. Lymphoreticular neoplasms were the most frequent neoplastic diseases observed. As these tumors mature, a large number of the malignant cells are intimately associated with fibers of the reticulum and appear to adhere to the walls of the capillaries in the mass being formed. Hepatomas appeared as large nodules of abnormal cells which developed within the liver, or ultimately the entire liver became a mass of these cells. Fathead minnows were grown in effluent taken from secondary treatment plants and effluent treated with disinfectants. The presence of polio virus in monkey kidney cultures plated with

intestinal tract homogenates of these fish was used as an indicator of sewage contamination and the effectiveness of the disinfectants. Polio viruses were found in the intestinal tracts of fish raised in untreated effluent and effluent treated with bromochloride and ozone. The viruses were not present in fish raised in effluent treated with chlorine. These results indicate that health hazards are associated with fish grown in sewage effluents. The toxicity of vinyl chloride was investigated in northern pike. The development of skin lesions in these fish is discussed. (7 Refs)

104. NEOPLASIA IN ROACH (RUTILUS RUTILUS L.) FROM A POLLUTED ENVIRONMENT.

Bucke D

Huntingdon Res. Centre, Huntingdon PE 18 6ES, England
Prog Exp Tumor Res; 20:205-211 1976

The incidence of tumors in a population of roach (Cyprinidae: Rutilus rutilus L.) inhabiting a lake fed by polluted streams is described. The streams pass through an area where open-cast, iron-ore mines are worked, and they receive sewage effluent and industrial wastes from steel works. The lake water contained up to 500 mg/liter calcium carbonate, and high concentrations of ammoniacal nitrogen and phenol. The most significant toxicant detected was zinc. Other heavy metals detected were copper, lead, and cadmium. Chromium and nickel were present in amounts too low for measurement. Tumors were found on roach only and not on the other two species present in the lake (Gasterosteus aculeatis L and Tinca tinca L.). Seven tumors, two of which were in the same fish, were found. One was a soft white mass, 3 cm in diameter, situated behind the operculum and attached to the bottom jaw. It had invaded the surrounding musculature and had histologic features of a thyroid neoplasm. The other tumor (2 cm in diameter) in the same fish was situated amid the gut convolutions and seemed to originate in the liver. No follicular pattern was seen in the tumor, and it is possible that it was a separate neoplasm rather than a metastasis from the thyroid tumor. The other five tumors were seen as small (0.5-2 cm in diameter) raised areas on the pharyngeal region between the lower jaws. They were composed of small, mainly solid follicles with little evidence of colloid secretion. There was invasion of the surrounding musculature and bone but no sign of metastasis. It is not possible to demonstrate whether pollution had any bearing on the incidence of tumors in the fish in this lake with such a limited investigation. It is pointed out that fish, which are the most common vertebrate, should be exploited more fully, particularly as indicators of pollution, by investigators in the field of neoplasia. (11 refs)

105. CARCINOGENS IN ESTUARIES, THEIR MONITORING AND POSSIBLE HAZARD TO MAN. (PP. 83-94)

Stich HF, Acton AB, Dunn BP

Environmental Pollution and Carcinogenic Risks. Lyon, International Agency for Research on Cancer, IARC Scientific Publications No 13, INSERM Symposia Series, vol. 52, 1976.

The feasibility of using bottom-dwelling flatfish populations and their skin tumors for examining the chemical carcinogens in subtidal or intertidal waters is examined. A trial procedure on the skin of lemon sole (Paraphrys vetulus) along the coast of British Columbia and Washington State showed that tumor prevalences varied from 0.0% to 58.6%. The higher values were found adjacent to cities. A study of papillomas on cresthead flounders (Limanda schrenki) in two locations in Japan, one free of industrial contamination and one containing heavy deposits of peat moss, showed an occurrence of papillomas about 24 times greater in the latter location than in the former. To complement this method of monitoring carcinogens indirectly by their effect on an indicator species, a direct laboratory method is developed by establishing a "carcinogen index" based on measurements of benzoapyrene (BaP) in water bottom sediments and in the common mussel (Mytilus edulis or Mytilus californianus). The Mytilis californianus was the most able, since it is widely distributed, readily sampled, nonmigratory, and adaptable to laboratory experiments. Using this method, docks and wharfs appear to show a notable elevation in BaP, thought to be the result of contamination by creosote. A three-tier assessment of mutagenic hazards is presented: the first tier is the short-term in vitro test; the second tier is the fish-tumor system; and the third is the detection of selected key compounds such as the B(a)P analysis in mussels. (24 Refs)

106. ORAL PAPILLOMAS IN GENYONEMUS LINEATUS (WHITE CROAKERS). ETIOLOGICAL CONSIDERATIONS.

Phillips ML, Warner NE, Puffer HW

Dept. Pathology, Sch. Medicine, Univ. Southern California, Los Angeles, CA 90033
Prog Exp Tumor Res ; 20:108-112 1976

Southern relationships between the biology and pathology of white croakers in Southern California coastal waters and in sewage discharge were investigated. Fin rot and oral papillomas were among the most frequently found pathologic conditions. Microscopically, the oral tumors were squamous papillomas. The surface was covered by stratified squamous epithelium that had occasional invaginations into the underlying stroma, suggesting that the lesion develops as an ingrowth of the surface covering. The tumor was composed of cystic spaces lined by orderly stratified squamous epithelium with a distinct basal layer. Waste discharges from the sewage effluents in the study area have not yet been adequately characterized with respect to chemical composition and known carcinogenic agents. Direct correlation between the occurrence of these papillomas and water quality has not been possible. There was no apparent difference, however, between the fishes sampled immediately surrounding sewage effluents in the open beach area and those from clean water stations in the same area. Observation of substrate, feeding habits, and incidence of tumors indicate that mechanical injury of the mouth of these fish during feeding may play a part in the etiology of the tumors. It is also possible that this mechanical abrasion simply opens the tissue to infectious agents or chemical irritants. (4 refs)

107. OCEAN WASTEWATER DISCHARGE AND TUMORS IN A SOUTHERN CALIFORNIA FLATFISH.

Mearns AJ, Sherwood MJ

Southern California Coastal Water Res. Project, 1500 East Imperial Highway, El Segundo, CA 90245
Prog Exp Tumor Res ; 20:75-85 1976

The incidence and characteristics of tumors in Dover sole in southern California waters were examined, and a series of regional studies on the sources, mass emission rates, distributions, and fates of chlorinated hydrocarbons and trace elements in coastal waters was conducted. Among the southern California demersal, trawl-caught fishes, the Dover sole is the only species consistently affected with epidermal tumors. The tumors are noninvasive and consist primarily of the size-related structural types, i .., angioepithelial nodules, epidermal papillomas, and angioepithelial polyps. Some affected specimens, however, had highly pigmented (almost black) papillomas, and one tumor was described as an invasive squamous cell carcinoma. Although the mass emission rate of total DDT from the Los Angeles County discharge on the Palos Verdes shelf has decreased by 80% from 1971 to 1973, it is estimated that there are still 200 metric tons of total DDT in the Palos Verdes sediments. The concentration of total DDT

decreases in all directions from the Palos Verdes shelf and these gradients are reflected in the muscle tissue of Dover sole. The Palos Verdes effluent is also high in trace elements. The overall incidence of tumor-bearing Dover sole in southern California trawl catches is 1%, and the species is most abundant on the Palos Verdes shelf. There appear to be no gradients in the distributions of tumor-bearing specimens, but Dover sole with eroded fins are strongly concentrated on the Palos Verdes shelf. It is concluded that the Dover sole skin tumor disease is ot enhanced by the discharge of municipal waste in southern California and would not be reduced in overall incidence by projected improvements in waste treatment unless such changes affected the survival or recruitment of juvenile Dover sole. (14 refs)

108. EPIZOOTIOLOGY OF PAPILLOMAS IN ENGLISH SOLE, PAROPHRYS VETULUS.

Cooper RC, Keller CA
U. California Sch. Pub. Health, Berkeley, CA
Natl Cancer Inst Monogr; 31:173-185 1969

Papillomas were found in 12% of 15,739 English sole (Parophrys vetulus) collected in San Francisco Bay from September, 1965-September, 1966. The tumor frequency varied from 3-28% in fish collected at different times and places, with a peak frequency in May-September. Since the tumors were distributed approx randomly on the body surfaces, it is suggested that the tendency to develop tumors may begin before metamorphosis. Tumor-bearing fish resembled normal fish in many respects, but apparently showed significant differences in the growth rate (which could not be attributed directly to a debilitating effect of the tumor on the host) and the time of birth. No such tumors were noted in flatfish of any of the other species (about 7) collected from San Francisco Bay. The possible role of a monogene trematode (Gyrodactilus sp), an ectoparasite found only on the English sole, is mentioned. Tumor-bearing fish were about twice as frequent in the North Bay as in the South Bay throughout the study period. The North Bay is shallower, with a larger fresh water inflow and more direct influence by industrial pollution (especially petrochemicals), than the South Bay. The possible existence of 2 populations of English sole in San Francisco Bay, differing from each other in either genetic factors or in exposure to environmental factors, is suggested.

109. DISTRIBUTION OF NEOPLASMS AND OTHER DISEASES IN MARINE FISHES RELATIVE TO THE DISCHARGE OF WASTE WATER.

Mearns AJ, Sherwood MJ
Southern California Coastal Water Res. Project, El Segundo, CA 90245
Ann NY Acad Sci; 298:210-224 1977

A study of approx 290,000 fish collected from southern California coastal waters between 1969 and 1976 showed that 5% were affected with fin erosion, tumors, color anomalies, or attached macroparasites. Fin erosion, which occurred at the highest frequencies and in the greatest number of species, was the only disease that appeared to be directly associated with the discharge of municipal wastewaters. Neither the lip papillomas of the white croaker nor the epidermal tumors of young Dover sole were related to single municipal wastewater discharge sites or to other discrete sources of pollutants. No skin tumors were observed in other pleuronectids, and the prevalence of lip papillomas in white croakers was lower than in past years. The prevalence of Pacific sanddabs with Phrixocephalus cincinnatus increased with distance from the Palos Verdes shelf, suggesting that the high chlorinated hydrocarbon levels in the tissues of fish at Palos Verdes are inimical to this attached macroparasite. (37 Refs)

110. COMPARATIVE ONCOLOGY AND ENVIRONMENTAL CARCINOGENS.

Dawe CJ
Bethesda, Md.
UICC Bull; 8(4):2-3 1970

Studies presently underway to investigate the development of neoplasms by aquatic animals and to elucidate possible etiological factors are reviewed. Bottom-feeding fish and filter-feeding mollusks provide test systems for investigating tumorigenesis by chemical water contaminants. Filter-feeders which accumulate many chemical contaminants in high concentrations in the course of ingesting food and the bottom-feeders which subsist on these mollusks demonstrate the carcinogenic properties of water contaminants. Epitheliomas developing in the mantles of the Sydney rock oyster are under study, as are carcinomas and papillomas developed by California coastal croakers. Eel papillomas and papillomas of fish such as the flounder and the sole are thought to be of viral origin. Neuroepitheliomas developed by Lake Michigan whitefish are also of interest in view of the extreme pollution of the Great Lakes. Lymphosarcomas developed by the northern pike, which is neither a bottom-feeder nor a scavenger, are also being studied.

2. Tumor Induction in Aquatic Organisms by Water Contaminants: Laboratory Studies

111. TUMOR INDUCTION BY CARCINOGENIC AGENTS IN ANURAN AMPHIBIAN RANA TEMPORARIA.

Khudoley VV
Lab. Chemical Carcinogenic Agents, N. N. Petrov Res. Inst. Onkology, Pesochnaya-2, Leningrad, 188646, USSR
Arch Geschwulstforsch; 47(5):385-395 1977

Twelve chemical carcinogens were administered to frogs (Rana temporaria) and studied for tumor induction. Dimethylnitrosamine, diethylnitrosamine, and dibutylnitrosamine dissolved in the drinking water (5, 50, and 5 ppm, respectively) induced tumors in 44.2%, 43.6%, and 50% of the animals, respectively. Benzidine and 2-acetylaminofluorene administered sc (45-114 mg and 25.5-58.5 mg, respectively) resulted in tumors in 46.4% and 41.2% of the animals; po doses of 60 mg and 30.5 mg, respectively, resulted in no significant tumor induction. P-dimethylaminoazobenzene and o-aminoazotoluene administered sc at doses of 37-82 mg and 35-80 mg, respectively, resulted in tumors in 30% and 33.3% of the animals, respectively; po administrations of 41 mg and 40.5 mg resulted in no significant tumor induction. Diethylstilbestrol propionate (480-4,400 ug, sc) induced tumors in 21% of the animals. All tumors developed within 15.6-31.9 wk, and they were located in the liver (hepatocellular cancer, hepatoadenomas) or the hemopoietic system (hemocytoblastosis). Administration of diethylhydrazine (sc and po), urethan (sc and po), carbon tetrachloride (sc), and 4-nitro-(2-furyl)-thiazolylformamide (sc) did not produce tumors. These findings indicate that there is a common mechanism of carcinogenesis in vertebrates and that these animals would be useful for carcinogenesis testing, possibly of environmental pollutants. (15 Refs)

112. TUMOR INDUCTION BY N-NITROSO COMPOUNDS IN BIVALVE MOLLUSKS UNIO PICTORUM.

Khudoley VV, Syrenko OA
N. N. Petrov Res. Inst. Oncology, Leningrad 188646, USSR
Cancer Lett; 4(6):349-354 1978

Exposure of bivalve mollusks (Unio pictorum) to diethylnitrosamine (DENA) and dimethylnitrosamine

(DMNA) dissolved in the tank water resulted in tumor formation. DENA induced tumors in 18% of the animals exposed to 200 ppm for 64 days and 68% of those exposed to 400 ppm for 62 days; the av latent periods were 71 and 61 days, respectively. DMNA induced tumors in 8% of the animals exposed to 200 ppm for 51 days and 27% of those exposed for 152 days, and av latent periods were 85 and 81 days, respectively. Neoplasms were observed in the digestive gland (basophilic cell tumors; 38 cases), the hemopoietic system (hemocytoblastoma: 12 cases), and the kidney (poorly differentiated carcinoma; 1 case). Tumors arose from the digestive glands on a background of diffuse and focal proliferation of basophilic cells. They were invasive and characterized by extraordinary pleomorphisms and atypia. Tumor incidence was dose-dependent. It is suggested that mollusks can be used to determine the carcinogenicity of N-nitroso compounds and to indicate possible water pollutants. (9 Refs)

113. ONCOGENIC AGENTS FOUND IN FISH INHABITING A POLLUTED WATER SYSTEM (MEETING ABSTRACT).

Brown ER, Keith L, Hazdra JJ, Sinclair TF
Chicago Med. Sch., Ill.
Proc Am Assoc Cancer Res; 15:22 1974

At previous meetings of this Association, we reported on the high frequency of tumors found in fish inhabiting a polluted water system (Canc Res 33: 189; 1973). This study will devote itself primarily to the high frequency of lymphosarcoma in the jaw and leukemia in Esox species (northern pike and muskellunge). Muskellunge and northern pike were found to have an incidence (11.1%) of 1 of 2 forms of leukemia. These leukemias can be transferred experimentally by means of cell-free filtrates by direct inoculation into susceptible animals. The lymphosarcoma in nature is found to have a frequency of 1.7% in polluted waters. We were able to transmit experimentally this disease to normal fish in the laboratory, confirming the earlier work of Mulcahy and others (Canc Res 30: 2712; 1970). A detailed description of the 2 leukemias, 1 a lymphosarcoma-leukemia similar to that in man and the other a unique leukemia of fish, is presented. Certain chemicals such as magnesium and phenylnitrosamine oxide at high levels (up to 200 ppm) in experimental tanks produced up to 25% epidermoid tumors in blue gills and perch. These experimental levels approach those found in the polluted waters.

114. ENHANCEMENT OF LYMPHOSARCOMA TRANSMISSION IN ESOX LUCIUS AND ITS EPIDEMIOLOGIC RELATIONSHIP TO POLLUTION.

Brown ER, Dolowy WC, Sinclair T, Keith L, Greenberg S, Hazdra JJ, Beamer P, Callaghan O
Chicago Medical Sch., Chicago, IL 60612
Bibl Haematol; (43):245-251 1976

The relationship between malignant tumors in fish and the degree of pollution of the waterways in which they live was compared in three waterways of greatly different pollution. The correlation was significant ($p < 0.01$). Northern pike (Esox lucius) developed tumors after they were inoculated with Mulcahy reticulum cell sarcoma. Apparently cell-free extracts also cause tumor production, supporting the hypothesis of the viral etiology of this tumor, although Millipore-filtered material failed to produce tumors in young fish. The speed of tumor development is affected by inoculum size and site, water temperature, and age of recipient fish. Poliovirus was isolated from the gut of several fish from polluted water.

115. A CONDITION SIMULATING LYMPHOMA ASSOCIATED WITH SPOROZOAN INFECTION IN CULTURED TURBOT (SCOPHTHALMUS MAXIMUS L.).

Ferguson HW, Roberts RJ
Unit Aquatic Pathobiology, Univ. Stirling, Stirling, Scotland
Prog Exp Tumor Res; 20:212-216 1976

An outbreak of a condition resembling lymphoma in 10% of the turbot in an experimental tank filled with warm water from a nuclear-power generation facility to maintain a constant summer growth rate temperature throughout the year is discussed. The lesions were scattered, but they were more frequent in the subcutis than elsewhere. Small lesions were generally of firm consistency, but larger lesions that had developed a thick fibrous capsule had a softer consistency, with the center often liquefied. Histologically, the lesions could be divided into 3 zones: (1) the periphery, which was comprised almost exclusively of nondifferentiated myeloid cells; (2) the center, which exhibited liquefactive necrosis and the basophilic remains of pyknotic nuclei; and (3) dendritic cells surrounding the liquefactive center. Material from the periphery was examined by electron microscopy, which indicated that the lesions consisted of macrophagelike cells containing protozoan parasites. Blood smears showed an increase of immature WBC, most of which were monocytes. No parasites were found in exposed, clinically healthy, fish. Although intracellular parasites were found in every case examined, it has not been possible to show a causal relationship. Background radiation levels are low in the facility, and there was no high incidence of neoplasia in other species of fish in the establishment. The relationship of any form of pollutant to the condition remains conjectural, but the possibility that pollutants had a bearing on susceptibility to the condition is supported by the finding that when flow rates were raised and stocking density was drastically reduced, its incidence fell dramatically. (No refs)

116. METABOLISM OF BENZO(A)PYRENE IN ANIMALS WITH HIGH ARYL HYDROCARBON HYDROXYLASE LEVELS AND HIGH RATES OF SPONTANEOUS CANCER.

Busbee DL, Guyden J, Kingston T, Rose FL, Cantrell ET
Dept. Biology, North Texas State Univ., Denton, TX, 76203
Cancer Lett; 4(2):61-67 1978

Aryl hydrocarbon hydroxylase (AHH) induction and benzo(a)pyrene (BP) metabolism were studied in salamanders (Ambystoma tigrinum) removed from a sewage-polluted pond, a population of animals with a high level of spontaneous tumors. Some of these animals were analyzed immediately for AHH content, and others were placed in clean, aerated water. Salamanders that had been maintained in the laboratory were induced with a single ip injection of 3-methylcholanthrene (MC; 10 mg/kg). Animals taken directly from the pond were found to have hepatic microsomal AHH levels about 80% as high as those of animals inoculated with MC. After animals were held in clean water for several months, their AHH levels were as low as those of control untreated laboratory salamanders. Microsomes from the salamanders were reacted with BP, and the metabolites were separated by high-pressure liquid chromatography. BP metabolites produced by salamander liver microsomes were qualitatively similar to those reported for mammals; however, the percentage of the metabolites appeared to differ significantly. Treatment of induced salamander microsomes with cyclohexene oxide or 1,2-epoxy-3,3,3-trichloropropane during incubation significantly changed the metabolic profile. The greatest effect was decreased diol production, indicating a normal epoxide

hydrase conversion of intermediate compounds to the diol form. these findings suggest that an inducing agent is present in relatively high concentrations in the polluted water, and that a correlation appears to exist between high AHH induction, the presence of polycyclic hydrocarbon pollutants, and the high spontaneous cancer rate in salamanders. (25 Refs)

B. Carcinogenicity Studies of Contaminants of Water Supplies in Experimental Animals

117. CHLORINATED DRINKING WATER. TOXICITY STUDIES IN SEVEN GENERATIONS OF RATS.

Druckrey H
Max Planck Inst., Freiburg i. Br., Germany
Food Cosmet Toxicol; 6(2):147-154 1968

Strongly chlorinated water (100 mg/liter free Cl), administered throughout life as drinking water to 7 generations of BDII rats, showed no toxic effects on growth, life span, fertility, blood picture or the histology of different organs (liver, spleen, kidneys); the incidence of malignant and benign tumors (24 and 8, resp) among the 236 experimental animals was the same as in the 56 controls (5 malignant and 2 benign tumors), approx. 10% in both groups. Noticeable in the treated rats was the occurrence of 15 metastasizing undifferentiated large cell lymphosarcomas of the ileocecal region, especially in the second generation (7 cases) but these were considered spontaneous tumors and not causally related to drinking of chlorinated water.

118. HARMFUL EFFECT OF WATER CHLORINATION WITH SPECIAL REGARD TO THE COCARCINOGENICITY OF CHLORINE. PART I: LITERATURE SURVEY.

Pfeiffer EH
Hygiene-Institut, Johannes-Gutenberg-Universitat, D-6500 Mainz, W. Germany
Zentralbl Bakteriol Orig B; 166(2/3):169-184 1978

Studies of the toxicological aspects of chlorine in water and certain foods are reviewed. In one experiment, seven generations of BD II rats received tap water containing 100 ppm chlorine ad libitum over a 9-yr period. Tumor incidence was the same (approx 10%) as that in controls, which received nonchlorinated water. (no Refs)

119. DEPRESSION OF MACROPHAGES IN MICE DRINKING HYPERCHLORINATED WATER.

Fidler IJ
Basic Res. Program, NCI-Frederick Cancer Res. Center, P.O. Box B, Frederick, MD 21701
Nature (Lond); 270(5639):735-736 1977

The possibility that hyperchlorination (25-30 ppm) of drinking water could adversely affect murine peritoneal exudate macrophages (PEM) was investigated, because difficulties occurred in the collection and in vitro activation of PEM at about the same time that chlorine levels in the water of the animal facility had been increased. C57BL/6N female mice were given tap water or hyperchlorinated water. Just before treatment, the number of peritoneal exudate cells (PEC) per mouse was 2! x 10^6. One week later, the number had decreased to 13 x 10^6 in mice receiving hyperchlorinated water but had increased to 25 x 10^6 in mice on tap water. PEM from mice on the two regimens were assayed for in vitro tumoricidal properties. PEM from mice on tap water were cytotoxic to syngeneic tumor target cells following treatment with concanavalin A-macrophage activating factor. PEM collected from hyperchlorinated mice had significantly lower levels of cytotoxicity during the first 2 wk of treatment, and they were not tumoricidal by the third. It is concluded that the addition of high levels of chlorine to the drinking water of mice produces profound alterations in the numbers of PEM and tumoricidal function. The findings raise the possibility that host resistance against neoplasms may also be compromised by hyperchlorinated drinking water. (21 Refs)

120. HEALTH EFFECTS OF ORGANICS: RISK AND HAZARD ASSESSMENT OF INGESTED CHLOROFORM.

Tardiff RG
Board on Toxicology and Environmental Health Hazards, Natl. Acad. Sciences, Washington, DC
J Am Water Work Assoc; 68(12):658-661 1977

Experimental data on chloroform carcinogenicity are reviewed, and their importance to man is discussed. In mice, 30 po doses of 0.4 or 0.8 ml/kg produced nonmetastasizing hepatomas and cirrhosis; however, a single sc injection of 200 ug chloroform was not carcinogenic. When Osborne-Mendel rats and B6C3F1 mice were given two doses of 90-200 mg/kg or 138-477 mg/kg, respectively, five times per week for 78 wk, kidney tumors resulted in male rats, liver tumors in male and female mice. There was a dose-related response in the animals developing tumors. Extrapolation of these findings to man is difficult and is complicated by the fact that there is no epidemiological evidence implicating chloroform as a human carcinogen. The problems of extrapolating from high- to low-dose levels and several methods of estimating risk are outlined. It is suggested that human exposure (via tap water) should not exceed 0.01 mg/kg/day (or 70 ppb). Chloroform exposure could account for as much as 1.6% of the liver cancer and 1.44% of the renal cancer incidence each year. It is estimated that 252/approx 300,000 cancer deaths each year are the result of chloroform in the tap water. (10 Refs)

121. CARCINOGENIC EFFECTS OF ADSORBATES OF RAW AND FINISHED WATER SUPPLIES.

Hueper WC, Payne WW
NCI, Bethesda, Md.
Am J Clin Pathol; 39(5):475-481 1963

Raw water studied was from a river downstream from chemical and rubber plants; approx 170 gallons yielded 1 g of chloroform extract and approx 1150 gallons yielded 1 g of an ethanol extract. In terms of finished water (from a town's drinking water), for similar quantities of chloroform and ethanol extracts, 620 and 890 gallons, respectively, were needed. After injection of chloroform eluates which contained the aromatic fraction of hydrocarbons from adsorbates of raw water (2 mg in 0.05 ml tricaprylin per 2 wk x 28, sc) into C57 mice, of 4/72 tumors which developed at the site of inj, 3 were spindle cell sarcomas; one developed a papilloma of the bladder. After cutaneous administration of 1 drop of this extract every 2 wk x 28, 1/72 developed a reticulum cell sarcoma of the liver and another developed leukemia or lymphoma. When chloroform extracts of finished water (4 mg in 0.05 ml tricaprylin, sc) were administered, 2/72 developed lymphoma or leukemia; no tumors developed from cutaneous admin. After cutaneous and sc (4 mg in alcohol every 2 wk x 20) of ethanol extracts (detergent and phenolic constituents) of raw water and sc administration of finished water each led to 1 case of lymphoma or leukemia. Some of the mice painted with the alcohol extract exhibited chronic epidermal ulcers revealing hyperplastic epidermis in the marginal sections. Cutaneous administration of alcohol extracts of finished water or oral administration of chloroform extracts did not produce tumors. The bladder papilloma points to probable contamination of the water from rubber manufacturing plants.

122. CASE STUDY 5: ALDRINE AND DIELDRIN SUSPENSION BASED ON EXPERIMENTAL EVIDENCE AND EVALUATION AND SOCIETAL NEEDS.

Epstein SS

Case Western Reserve Medical Sch., Cleveland, OH 44106

Ann NY Acad Sci; 271:187-195 1976

The carcinogenicity of dieldrin has been unequivocally demonstrated in independent studies using several strains of mice. These data largely relate to hepatocarcinogenicity, but some evidence of extrahepatic multiple site neoplasms has also been found. Dieldrin was carcinogenic at the lowest dosage tested, 0.1 ppm. More limited studies in the rat clearly indicate that dieldrin is carcinogenic; one study demonstrated the induction of liver cancers and of multiple site tumors. Other studies in rats, monkeys, and dogs were rejected by the author for methodological inadequacies. Limited industry studies of occupationally exposed adult males also point to its carcinogenicity. The experts are unanimous in that the data accumulated so far cannot validate the noncarcinogenicity of dieldrin. As dieldrin exposure is involuntary, and as it constitutes a widespread contaminant of food, air, and water, the author feels that dieldrin presents an imminent hazard to exposed populations.

123. TEST FOR CARCINOGENICITY OF ORGANIC CONTAMINANTS OF UNITED STATES DRINKING WATERS BY PULMONARY TUMOR RESPONSE IN STRAIN A MICE.

Theiss JC, Stoner GD, Shimkin MB, Weisburger EK

Dept. Community Medicine, M-014, Sch. Medicine, Univ. California, San Diego, La Jolla, CA 92093

Cancer Res; 37(8,part1):2717-2720 1977

The production of lung adenomas in strain A mice following multiple ip injections of selected organic water contaminants was investigated. Of the 16 contaminants tested, only bromoform produced a pulmonary adenoma response that was significantly greater than the pulmonary adenoma response of vehicle-treated control mice. (Author abstract) (19 Refs)

C. Mutagenicity Studies of Water Contaminants

124. THE MUTAGENIC ACTIVITY OF HALOGENATED COMPOUNDS FOUND IN CHLORINATED DRINKING WATER.

Simmon VF, Tardiff RG

Microbial Genetics Program, Stanford Res. Inst. International, Menlo Park, CA, 94025

Water Chlorination; 2:417-431 1978

The mutagenic activities of 22 halogenated compounds found in chlorinated drinking water were determined using the Ames Salmonella/microsome procedure with S. typhimurium strains TA1535 and TA100. Two known carcinogens, carbon tetrachloride and chloroform, were not mutagenic in this system, probably because mutagenic metabolites were formed in insufficient amounts or they were so unstable that they did not survive long enough to penetrate the bacteria and interact with the DNA. Known carcinogens that were mutagenic were vinyl chloride, vinylidine chloride, 1,2-dichloroethane, 1,1,2-trichloroethylene, bis-(2-chloroethyl)ether, methyl iodide, and bromoform. Mutagenic activity was also observed with bromodichloromethane, chlorodibromomethane, methylene bromide, bromochloromethane, methylene chloride, methyl bromide, methyl chloride, 2-chloropropane, 1-chloropropene, bis(2-chloroisopropyl)ether, n-butyl bromide, t-butyl bromide, and s-butyl bromide. The results indicate that the number and amount of alkyl halides in potable water should be reduced to lessen possible health hazards. (20 Refs)

125. MUTAGENIC POTENTIAL OF PETROLEUM BYPRODUCTS IN CHESAPEAKE WATERS.

Voll MJ, Isbister JD, Isak LI, McCommas MD

Maryland Univ., Water Resources Res. Center., College Park, MD

Gov Rep Announce Index; 77(17):155,156 1977

Chesapeake Bay water and sediment samples from an oil polluted area (Colgate Creek) and a relatively non-polluted area (Eastern Bay) were assayed by the Ames bacterial system for the presence of mutagenic substances. The samples examined were collected in October and November of 1975 and in March, May and June of 1976. Organic extracts and/or untreated samples were assayed. Results suggest but do not establish the presence of mutagenic substances in Colgate Creek water and in sediment. (Author abstract) (no Refs)

126. EFFECTS OF MICROBIAL ACTIVITY ON AQUATIC POLLUTANTS.

Voll MJ, Isbister J, Isaki L, McCommas M, Colwell RR

Dept. Microbiology, Univ. Maryland, College Park, MD 20742

Ann NY Acad Sci; 298:104-110 1977

Water and sediment samples from a heavily oil polluted area of the Chesapeake Bay were analyzed for mutagenicity by the Ames test. Potential mutagens and/or carcinogens were not detected in the microbial degradation products of these oil extracts. Mutagenic substances may be present, but at concentrations below the detection level of the assay. (20 Refs)

127. INVESTIGATION OF MUTAGENIC EFFECTS OF PRODUCTS OF OZONATION REACTIONS IN WATER.

Cotruvo JA, Simmon VF, Spanggord RJ

Office Water Supply, U.S. Environmental Protection Agency, Washington, DC 20460

Ann NY Acad Sci; 298:124-140 1977

Twenty-eight compounds were subjected to extensive ozonation in water (ie, conditions more severe than those used in water treatment), and the toxicity and mutagenicity of the reaction products were tested in Salmonella typhimurium and Saccharomyces cerevisiae. Only ethanol, benzidine, phenol, 1,1-diphenylhydrazine, showed some level of mutagenicity after ozonation. The activity usually resulted only after prolonged ozone exposure, was not dose-related, and was not always repeatable. (5 Refs)

128. EXAMINATION OF DRINKING WATER FOR MUTAGENIC ACTIVITY.

Glatz BA, Chriswell CD, Arguello MD, Svec HJ, Fritz JS, Grimm SM, Thomson MA

Dept. Food Technology and Bacteriology, Iowa State Univ., Ames, Iowa

J Am Water Works Assoc; 70(8):465-468 1978

The Salmonella-mammalian microsome assay (Ames Test) was used to determine the mutagenic activity of organic contaminants in samples of drinking water from 14 major US water utilities. Monthly samples of both rough and finished water were prepared by isolating the organic contaminants from 200 liter samples on ion exchange and carbon columns, and concentrating with diethyl ether to 1.0 ml. Salmonella strains used for the Ames test were TA98, TA100, TA1535, TA1537, and TA1538. Eleven of fourteen finished water sources exhibited mutagenic activity. In four of these instances, both raw and finished water caused mutation in TA100, and in four others mutagenic activity was present only in finished water. One source was mutagenic against strain TA98 in raw, but not finished water. Addition of liver fraction S-9 served to activate potential mutagens in 9/12 cited instances. (18 Refs)

129. EVALUATION OF ORGANIC EXTRACTS OF DRINKING WATER BY BACTERIAL MUTAGENESIS (MEETING ABSTRACT).

Loper JC, Schoeny RS, Tardiff RG
Dept. Microbiology, Univ. Cincinnati Medical Center, Cincinnati, OH

Mutat Res; 53(2):223-224 1978

Tap water from several cities of the U.S. chosen as representing different water sources, ie, related to industrial waste, municipal waste, agricultural drainage, drainage of natural humus, or ground water, was processed by the procedure of F. C. Kopfler to yield extracts of concentrated organics. Portions of each sample were further fractionated using hexane, ethyl ether and acetone according to the method of R. G. Melton. Each sample and subfraction was dissolved in dimethylsulfoxide and tested for mutagenesis using Salmonella typhimurium strains TA98 and TA100. Mutagenicity was detected for each city. The effect was not enhanced and generally was decreased by the presence of an Aroclor 12-54-stimulated rat-liver microsome activation system. Samples from each city showed bacterial toxicity. In most cases a mutagenic doubling dose could be derived from dose-response data. Among the 5 cities, differences were obtained in terms of total mutagenesis per standard amount of water processed, relative mutagenicity-bacterial toxicity, selective mutagenesis of TA98 or of TA100, and recovery and distribution of mutagenic activity upon fractionation. (2 Refs)

130. MUTAGENIC ACTIVITY OF CHEMICALS IDENTIFIED IN DRINKING WATER (MEETING ABSTRACT).

Simmon VF, Kauhanen K, Mortelmans K, Tardiff R
Stanford Res. Inst., Menlo Park, CA

Mutat Res; 53(2):262 1978

Approx 300 chemicals have been identified in finished drinking water in the US. Some of these chemicals are known to be carcinogens in rodents (eg, aldrin, carbon tetrachloride) and/or humans (benzopyrene). We have begun to analyze these chemicals for their mutagenic activity in micro-organisms. Of 128 chemicals that we have tested, 21 were mutagenic in preliminary spot tests on Salmonella typhimurium TA100 (without metabolic activation). We have obtained dose-dependent mutagenic responses with 19 of these compounds (benzopyrene, bromochloromethane, bromodichloromethane, bromoform, bromomethane, n-butyl bromide, sec-butyl bromide, tert-butyl bromide, technical grade chlordane, chlorodibromomethane, bis(2-chloroethyl) ether, dibromomethane, 1,2-dichloroethane, 1,1-dichloroethylene, hexachloro-1,3-butadiene, iodomethane, methyl chloride, methylene chloride and vinyl chloride) in strains of S typhimurium. Additional mutagenicity assays using Escherichia coli WP2 and Saccharomyces cerevisiae D3 are underway. (no Refs)

131. MUTAGENICITY OF COMPLEX MIXTURES FROM DRINKING WATER.

Loper JC, Lang DR, Smith CC
Dept. Microbiology, Univ. Cincinnati Coll. Medicine, Cincinnati, OH, 45267

Water Chlorination; 2:433-450 1978

Residual organics concentrated from drinking water samples from five cities (Miami, Florida; New Orleans, Louisiana; Ottumwa, Iowa; Philadelphia, Pennsylvania; and Seattle, Washington) were tested for mutagenesis in the Salmonella/microsome system and for their ability to transform mouse BALB/3T3 1-13 cells. Each sample was processed sequentially to produce the reverse osmosis concentrate-organic extract (ROC-OE) and an ethanol-soluble eluate obtained from a macroreticular resin XAD-2 column (XAD eluate). Mutagenicity was detected for ROC-OE's from each city, the patterns being relatively stable for samples taken at 2-to 3-mo intervals. The ROC-OE's showed city-specific patterns regarding relative mutagenicities for S. typhimurium strains TA98 and TA100, relative amount of mutagenicity per milligram of residue, and distribution of mutagenic activity after fractionation. Metabolic activation produced little or no enhancement of mutagenic activity. ROC-OE fractions were 10-to 20-fold more toxic than the corresponding XAD eluates. Comparison of the transforming ability of a New Orleans ROC-OE with that of the known carcinogen 3-methylcholanthrene showed that the ROC-OE caused higher transformation rates at concentrations of 10-100 ug/ml. (12 Refs)

132. RESIDUE ORGANIC MIXTURES FROM DRINKING WATER SHOW IN VITRO MUTAGENIC AND TRANSFORMING ACTIVITY.

Loper JC, Lang DR, Schoeny RS, Richmond BB, Gallagher PM, Smith CC
Dept. Microbiology, Coll. Medicine, Univ. Cincinnati, Cincinnati, OH, 45267

J Toxicol Environ Health; 4(5/6):919-938 1978

Residual organic samples were concentrated from drinking water from representative US cities by reverse osmosis followed by liquid-liquid extraction and sorption-desorption on resin. City-specific patterns of dose-dependent bacterial mutagenesis and of bacterial toxicity were observed for these samples and for subfractions generated by sequential extractions. Mutagenicity was essentially independent of microsomal activation. One fraction of a New Orleans sample transformed BALB/3T3 cells in replicate experiments. (23 Refs)

133. INDUCTION OF BENZO(A)PYRENE MONO-OXYGENASE IN FISH AND THE SALMONELLA TEST AS A TOOL FOR DETECTING MUTAGENIC/CARCINOGENIC XENOBIOTICS IN THE AQUATIC ENVIRONMENT.

Kurelec B, Matijasevic Z, Rijavec M, Alacevic M, Britvic S, Muller WE, Zahn RK
Lab. Marine Molecular Biuology, Center Marine Res., Rudjer Boskovic Inst., P.O. Box 1016, 41001 Zagreb, Yugoslavia

Bull Environ Contam Toxicol; 21(6):799-807 1979

The induction of benzo(a)pyrene monooxygenase (BPMO) following the ip injection of young carp (Mugil cephalus) with polluted water extracts and the testing of these extracts in the Salmonella/microsome mutagenicity test using liver homogenates of pollution-induced fish were evaluated as an assay for detecting xenobiotics in aquatic environments. Injection of the following substances induced BPMO activity in young carp within 1-2 days: benzo(a)pyrene (BP), 25 and 50 ug; aflatoxin, 25 ug; crude oil, 50 ul; hexane extract of charcoal-filtered seawater (HESW), 50 ul, + crude oil, 50 ul; and HESW 50, collected from the mixing zone 50 m off a cannery outlet, 50 ul. Carp caught in the mixing zone had extremely high BPMO activity (1,600 units), but three specimens caught in clean areas had activities of only 65, 71, and 52 units. This indicates that the BPMO in the specimens caught in the mixing zone was induced by substances in the fish cannery effluent. In the mutagenicity assay, neither HESW, aflatoxin, nor BP was mutagenic in the absence of a liver postmitochondrial fraction. HESW 50, but not HESW 500 (collected 500 m from the cannery outlet), induced BPMO in carp and was mutagenic for Salmonella when the liver fraction from HESW 50-treated carp was added. The max mutagenic effect of HESW was seen with the liver fraction from carp from the mixing zone, but this liver fraction also produced revertants without a substrate. It is concluded that

the ip injection of polluted water extracts into carp followed by determination of BPMO induction plus the Salmonella assay can be used to detect mutagenic and/or carcinogenic xenobiotics in the aquatic environment. (23 Refs)

134. STUDY OF THE MUTAGENIC POTENTIAL OF BIS(2-CHLOROETHYL) AND BIS(2-CHLOROISOPROPYL) ETHERS IN MICE BY THE HERITABLE TRANSLOCATION TEST (MEETING ABSTRACT).

Jorgenson TA, Rushbrook CJ, Newell GW, Tardiff RG
Stanford Res. Inst., Menlo Park, CA
Mutat Res; 53(1):124 1978

Among the various chemicals identified by the Environmental Protection Agency in drinking water are bis(2-chloroethyl) ether and bis(2-chloroisopropyl) ether. Heritable translocation tests in mice were conducted to determine the mutagenicity of these two compounds. Adult male mice were treated by gavage, daily for 8 wk, at three dose levels per compound. Reference controls were included as well as a positive control group receiving triethylenemelamine (TEM) in the drinking water for 4 wk. After treatment, each male was mated to two virgin females to produce an F1 generation, the males of which were raised to maturity. One hundred F1 males per treatment group then were selected and bred to three virgin females each. The pregnant females were evaluated against predetermined selection criteria to identify suspect F1 males. These suspect F1 males then were rebred to three additional virgin females each. Presumptive F1 males after two breedings then were examined cytogenetically. All breeding data were evaluated and correlated with cytogenetic examinations. No positive reciprocal translocations were observed in the control or bis(2-chloroethyl) ether-treated groups. Preliminary evaluation of the data suggests that heritable translocations did not occur in either bis chloro ether compound.

135. DETECTION OF CHEMICAL MUTAGENS BY THE DOMINANT LETHAL ASSAY IN THE MOUSE.

Epstein SS, Arnold E, Andrea J, Bass W, Bishop Y
Child. Cancer Res. Found., Inc., Boston, Mass.
Toxicol Appl Pharmacol; 23(2):288-325 1972

A total of 174 test agents, including pharmaceuticals, food additives, pesticides, and organic extracts of air and water pollutants, was tested for mutagenicity in mice. Only 16 agents induced unequivocal effects on early fetal deaths and/or total implants, as confirmed by analysis of variance and by consistency of results; of these, 12 were considered mutagenic in that they increased the number of early fetal deaths with or without preimplantation losses. The 4 others, actinomycin D, Niridazole, colchicine, and mitomycin C, caused significant reduction in number of total implants, but no significant increase in early deaths. Isopropyl methanesulfonate, METEPA, methyl methanesulfonate, Myleran (Busulfan), TEPA, thio-TEPA, triethylenemelamine (Persistol), and trimethyl phosphate caused significant time- and dose-related effects on both the number of total implants and the number of early deaths. Cyclophosphamide (Cytoxan) and ethyl methanesulfonate induced significant and dose-related increases in the number of early deaths, as did 2 air pollutant fractions. (20 refs)

V. PUBLIC HEALTH ISSUES AND REGULATION OF CARCINOGENIC CONTAMINANTS OF WATER SUPPLIES

136. DRINKING WATER AND HEALTH: RECOMMENDATIONS OF THE NATIONAL ACADEMY OF SCIENCES.

Blum B
Criteria and Standards Div., Office of Water Supply, Environmental Protection Agency, Washington, DC 20460
Fed Regist; 42(132):35764-35779 1977

Recommendations of the National Academy of Sciences concerning the contamination of water supplies with harmful substances are summarized. Four principles relevant to the assessment of risk from long-term exposure to carcinogenic substances at low doses are outlined: (1) effects in animals, properly qualified, are applicable to man; (2) methods to establish a threshold for long-term effects of toxic agents are not in existence; (3) the exposure of experimental animals to high doses of toxic agents is a necessary and valid method of discovering possible carcinogenic hazards in man; (4) materials should be assessed in terms of human risk, rather than as safe or unsafe. Risk estimates have been made for some known water supply contaminants for which data were available. Estimates of lifetime cancer risks (with a 95% upper confidence limit) are 5.1×10^{-7}, 2.6×10^{-4}, 4.4×10^{-4}, 1.2×10^{-6}, 3.1×10^{-6}, and 3.7×10^{-7} (expressed as risk/ug/liter) for vinyl chloride, dieldrin, kepone, DDT, polychlorinated biphenyls (with data for arochlor 1260), and carbon tetrachloride, respectively. The highest observed concentrations in drinking water of these substances are 10, 8, unknown, unknown, 3, and 366 ug/liter, respectively. The max observed levels of a large number of organic pesticides and other organic contaminants in drinking water are listed, together with recommended acceptable daily intake levels. (no Refs)

137. DRINKING WATER AND HEALTH. PART I, CHAPTERS 1-5. A REPORT OF THE SAFE DRINKING WATER COMMITTEE.

Author not identified
Committee Public Information, Prevention Occupational Cancer, Natl. Res. Council, Washington, DC
Gov Rep Announce Index; 77(21):100 1977

The Safe Drinking Water Act of 1974 (PL93-523) required the Administrator of the Environmental Protection Agency to arrange for a study that would serve as a scientific basis for revising the primary drinking water regulations that were promulgated under the Act. The study was conducted by the Safe Drinking Water Committee of the National Research Council. A thorough study of the scientific literature was undertaken in order to assess the implications for human health of the constituents of drinking water in the United States. Assessment of the health benefits and the economic or technological feasibility of achieving a given level of contaminant control is outside the scope of the study, although the beneficial effect of some constituents of drinking water is considered. Three classes of contaminant were examined: microorganisms, particulate matter, inorganic solutes. (Author abstract) (no Refs)

138. DRINKING WATER AND CARCINOGENESIS: THE DILEMMAS.

Ibrahim MA, Christman RF

Dept. Epidemiology, Sch. Public Health, Univ. North Carolina, Chapel Hill, NC 27514

Am J Public Health; 67(8):719-720 1977

Problems associated with establishing a definitive link between water-borne chemicals and cancer are discussed. The number of complex and interrelated factors is too great to determine the carcinogenicity of a specific substance, and extrapolation of animal studies may not be meaningful. Governmental decisions regarding the acceptibility of public health risks should be based upon stronger scientific evidence than is presently available. (1 Refs)

139. NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS FOR RADIOACTIVITY (MEETING ABSTRACT).

Sullivan RE

Office of Radiation Programs, United States Environmental Protection Agency, Washington, DC, 20460

Health Phys; 35(6):917-918 1978

Under the Safe Drinking Water Act (PL 93-523), the Environmental Protection Agency was charged by the Congress with establishing drinking water regulations to protect health to extent feasible, after taking the cost of water treatment into consideration. Following a public hearing and consideration of written comments received over an extended period, interim regulations for radionuclides were promulgated on July 9, 1976. These regulations apply to community water systems serving residential structures, and become effective on June 24, 1977. This presentation reviews the Maximum Contaminant Levels (MCL) and monitoring schedules required under the regulations. In addition, the applicability of the various MCLs to systems having differing water sources and number of users will be surveyed. The reasons for excluding certain radionuclides from the current set of regulations are also discussed. Major changes made to the proposed regulations as a result of public comment are described as they lend some insight to the final form of the interim regulations. The regulations are based on a balancing of health effects, available treatment methods and their costs, existing and probable future levels of radioactivity in community water systems and the estimated monitoring and compliance costs. The rationale behind the MCLs and the general procedure followed in deriving 'screening' levels for future analysis will be outlined. The questions most frequently raised in this context are to be summarized and discussed. (no Refs)

140. IS EPA'S RADIUM-226 DRINKING WATER STANDARD JUSTIFIED?

Riddiough CR, Musselman R, Calabrese EJ

Sch. Public Health, Univ. Illinois Medical Center, Chicago, IL

Med Hypotheses; 3(5):171-173 1977

A proposal by the Environmental Protection Agency (EPA) to increase the permissible drinking water standard for ^{226}Ra from 3 to 5 picocuries/liter is reviewed, and four methodologies for estimating carcinogenic risk due to ^{226}Ra are compared. The EPA uses linear extrapolation models to estimate risks for low doses and low dose rates of high-LET (linear energy transfer) radiation; this approach may underestimate the risks. However, there is agreement between linear extrapolation models and epidemiological risk. Since those most at risk are the very young, because of their high mitosis rate and long life expectancy, it is not felt that the increase in ^{226}Ra exposure is justified on a human health basis. (17 Refs)

141. OCCUPATIONAL AND ENVIRONMENTAL STANDARDS FOR ASBESTOS AND THEIR RELATION TO HUMAN DISEASE. (PP. 1785-1796)

Nicholson WJ

Mount Sinai Sch. Medicine, City Univ. New York, New York, NY, 10029

Human Risk Assessment, Proceedings of the Cold Spring Harbor Conferences on Cell Proliferation. Vol. 4 (Book C), Hiatt HH, Watson JD, Winsten JA, ed. Cold Spring Harbor, Cold Spring Harbor Laboratory, Origins of Human Cancer., 583 pp., 1977.

The effectiveness of occupational and environmental asbesto standards is considered. The current occupational standard for asbestos is a time-weighted av exposure limit of 2 fibers/ml. Additional provisions for controlling exposures based on work practices are included in this standard, but they are mandatory only if the asbestos air concentration exceeds the established value. Extrapolation from studies on the relationship between lung cancer and exposure of workers in asbestos plants indicates that a continuous 20-yr fiber exposure of 0.4 (less than the proposed Department of Labor standard of 0.5 fibers/ml) could cause a fourfold increase in lung cancer. The ambient-air standard for asbestos simply states that there can be no visible emissions from any facility producing or using asbestos materials. Exposure of the general population occurs from the fireproofing of office buildings by spraying with material containing up to 15% asbestos a practice no longer permitted. However, the demolition of such buildings, the erosion of fibers from previously applied asbestos, and damage to asbestos during repair work pose serious exposure problems now and in the future. No standards exist for asbestos levels in water supplies, which range from less than 0.1 to greater than 200 ug/liter. Although no direct epidemiologic evidence links ingestion of asbestos to gastrointestinal cancer, an excess of such tumors has been found among asbestos workers. There are also no appropriate standards for the use and disposal of mining and quarrying material contaminated with asbestos fiber or for the use of asbestos in consumer products. (17 Refs)

142. ASBESTOS AND ITS ENVIRONMENTAL IMPACT.

Horvitz JS

U. Connecticut, Storrs, CT

Environ Aff; 3(1):145-165 1974

There is a definite relationship between exposure to asbestos and diseases such as asbestosis, lung cancer, gastrointestinal cancer, and mesothelioma. It is estimated that at least 2310 asbestos related deaths occur each year in the United States. The legal and regulatory measures which have been taken to reduce the health hazards associated with asbestos exposure are reviewed with reference to the Occupational Safety and Health Act, the Clean Air Act, standards regulating the presence of asbestos in food, drinks, and drugs, and the pollution of water by asbestos. The legal and regulatory response to the environmentally deleterious effects of asbestos contamination have been inadequate, and there is a current need to promulgate strict laws and regulations to curve the ubiquitous use of these fibers. There is also a need for more complete medical studies relating asbestos exposure to various disease processes.

143. IS THE NITRATE DRINKING WATER STANDARD UNNECESSARILY LOW? CURRENT RESEARCH INDICATES THAT IT IS.

Parsons ML

Dept. Chemistry, Arizona State Univ., Tempe, AZ, 82581

Am J Med Technol; 44(10):952-954 1978

A revision of the proposed Environmental Protection Agency standards for nitrate in drinking water is recommended in view of the high cost of compliance with these

standards and the failure of recent studies to support reports of nitrate-induced methemoglobinemia in infants. The synergistic effect of the high bacteria in some well water is a necessary ingredient for infant methemoglobinemia previously linked only to nitrate intake. In a recent study, infants fed on a formula containing high nitrates but low bacteria content failed to become anemic; the conclusion is that nitrates alone do not cause methemoglobinemia. In the past 17 yr, there have been no reported fatalities from methemoglobinemia and few, if any, cases of the disease associated with the ingestion of municipal waters have been reported in the United States. Large amounts of nitrate are regularly ingested in vegetables. An increase in the permissible level to at least 100 ppm nitrate is recommended. (18 Refs)

144. DRINKING WATER: GETTING RID OF THE CARBON TETRACHLORIDE.

Marx JL
No affiliation given
Science; 196:632-636 1977

The efforts of the Environmental Protection Agency (EPA) to control the contamination of the Ohio and Kanawha rivers by carbon tetrachloride are reviewed. These rivers provide the water for 18 water companies serving 1.8 million persons. As a result of high concentrations of CCl4 in Cincinnati drinking water and in a 70-ton "slug" flowing down the Ohio River (240-340 ppb), EPA invoked a law which requires an industry to supply the agency with data on its discharges and to participate in a 45-day monitoring survey against four industrial companies. One of the companies refused to cooperate in the survey and by January 1977 had increased its discharge of CCl4 to about 4,000 pounds/day. The company was then closed by a court order and allowed to reopen only after agreeing to a spill prevention program. Chemical concentrations in the rivers have now returned to background levels of a few ppb, but the issue of whether public health was endangered is unresolved. (0 Refs)

145. INTERNATIONAL COOPERATION IN STUDYING THE HEALTH ASPECTS OF ORGANIC CONTAMINANTS IN INDIRECTLY REUSED WASTE WATER.

Zoeteman BC
Natl. Inst. for Water Supply, World Health Organization, Leidschendam (The Hague), The Netherlands
Ann NY Acad Sci; 298:561-573 1977

International cooperation in studying the health aspects of organic contaminants in indirectly reused waste water is discussed. Historical events concerning this problem are reviewed. Studies presently underway in Western Europe to establish data banks and appropriate legislation to eliminate or reduce contamination of water by persistent or carcinogenic materials are reviewed. The occurrence of organic contaminants in drinking water is discussed and the frequency of organic contaminants in drinking water by chemical class is tabulated. Continuous communication between national groups that are conducting epidemiologic studies on indirect reuse of waste water for potable water supply is encouraged. Such programs are currently in operation or planned in the United States, England, South Africa, and The Netherlands. Regulatory programs on environmental chemicals in Europe are reviewed. Standard test methods for toxicity of tap water should be developed as soon as possible, and specific criteria for residual toxicity of water must be developed. An internationally accepted methodology for contamination studies should be established so the results obtained in one country may be extrapolated to the problems of other countries. (24 Refs)

146. ESTIMATION OF RISK FROM CARCINOGENS IN DRINKING WATER.

Handy RW
Res. Triangle Inst., Research Triangle Park, NC
Estimation of Risk from Carcinogens in Drinking Water. Available from National Technical Information Service, Springfield, Va., as PB-283 174/1GA, EPA/600/2-78/107, 44 pp., 1978.

The report gives results of a study aimed at developing a means for estimating cancer mortality as a function of carcinogen concentration in drinking water. Cancer risk data for cigarette smokers was treated by the method of standard additions to provide an estimate of ambient carcinogen levels in drinking water. A similar treatment was carried out on lung cancer risk data to give an estimate of carcinogen levels in ambient air. (Author abstract)

147. TOXICOLOGY AND DRINKING WATER CONTAMINANTS.

Stokinger HE
Natl. Inst. Occupational Safety and Health, Robert A. Taft Labs., Center Disease Control, U.S. Public Health Service, Cincinnati, OH
J Am Water Work Assoc; 69(7):399-402 1977

The concept of a threshold level of exposure to carcinogens and the extrapolation of carcinogenesis data from animal studies to man are discussed. It is contended that the threshold level (below which no biological response is observed) is a valid concept in carcinogenesis and that genetic inborn errors of metabolism may cause a shift in carcinogen thresholds. This genetic basis may underlie the susceptibility of certain exposed workers to the induction of liver hemangiomas by vinyl chloride (ie, 50 cases of hemangioma were reported among 25,000 heavily exposed workers). It is also stated that fallacies are involved in the extrapolation of data from high-dose animal experiments to normal low-dose human situations. This point is illustrated by a discussion of chloroform carcinogenesis. Chloroform levels currently found in drinking water are not believed to constitute a danger to health. (27 Refs)

148. THE ARMY'S DRINKING WATER SURVEILLANCE PROGRAM.

Sneeringer PV, Belkin F, Straffon N, Costick SA
U. S. Army Environmental Hygiene Agency, Aberdeen Proving Ground MD 21010
Environ Sci Technol; 11(8):767-771 1977

Developments in the army's drinking water surveillance program are reviewed. Topics discussed include the information transfer system, the quality assurance program, quality control and water testing, anion/cation balancing, the data transferral system, and results of the surveillance program. (4 Refs)

VI. REVIEWS ON CARCINOGENIC CONTAMINANTS OF WATER SUPPLIES

149. PHYSIOLOGICAL EFFECTS OF TRACE ELEMENTS AND CHEMICALS IN WATER.

Varma MM, Serdahely SG, Katz HM
Bio-Environmental Engineering and Sciences, Howard Univ., Washington, DC
J Environ Health; 39(2):90-101 1976

The physiological effects of trace amounts of water pollutants are discussed. Although mercury, cadmium, lead, beryllium, chromium, manganese, and fluoride are all toxic to humans, they have not been implicated in human

carcinogenesis. Tumors have been induced in rat kidneys following chronic administration of lead in their drinking water. There is a correlation between a high incidence of skin cancer and high arsenic levels in drinking water. The consumption by infants of water with a high nitrate concentration may result in the production of nitrosamines, which can lead to stomach cancer. Many organic residues found in water have been linked to cancer in animals and/or humans. Polychlorinated biphenyls induced bladder cancer in rats. Commercial 1-naphthylamine contains up to 10% 2-naphthylamine, a known carcinogen. N-nitroso compounds are highly carcinogenic, and they also induce chromosomal breaks and aberrations. Urethane and certain other carbamates cause mutation, chromosome breaks, teratogenic effects, and cancer in test organisms. Of the 66 chemicals whose concentrations have been measured in water, 15/33 examined were carcinogenic in one or more animal tests. Of 430 potential pollutants, 17/87 examined were carcinogenic. (61 Refs)

150. DISTRIBUTION OF CHEMICAL CARCINOGENS IN AQUATIC ENVIRONMENTS.

Kraybill HF
NCI, NIH, Bethesda, MD 20014
Prog Exp Tumor Res ; 20:3-34 1976

Various contaminants in raw and finished water supplies that may have impact on the health of marine animals and man are reviewed, and specific categories of pollutants are considered. The organochlorine insecticides appear to demonstrate the greatest potential for a tumorigenic response. From bioassay data, DDT and chlordane could be classified as suspect carcinogens. A polychlorinated biphenyl (Aroclor 1260) has induced hyperplastic nodules with histological evidence for carcinomas in female rat livers. Polycyclic aromatic hydrocarbons are ubiquitous in the aquatic environment and may present the greatest carcinogenic insult. If these chemicals are discharged into waterways solubilized in solvents, there may be some miscibility or they may precipitate out of the solution. A few of the compounds are: auramine, benzidine, o-tolidine, 3,3'-dimethylbenzidine, and 2-naphthylamine. The effect of benzene on marine animals should be observed especially since it is a leukemogenic agent. It may occur at low concentrations as a contaminant in water from refinery wastes or intentional dumping. A systematic monitoring of aerial discharge and water effluents around plants producing vinyl chloride and polyvinyl chloride showed that values could range from 0.15-327 ppm. The fact that vinyl chloride has been detected and concentrations have been measured in waterways suggests that marine animals could be adversely affected and that vinyl chloride might be included in marine foods taken from contaminated waters. Some correlations have been found between levels of carcinogenic metals in certain river basins in the US and cancer mortalities in the region. Nickel concentration seemed to correlate with mouth and intestinal cancer death rates and arsenic with eye and larynx cancers and myeloid leukemia. Beryllium was correlated with bone cancer and mortalities from breast and uterine cancer. Lead was associated with kidney cancer, leukemias, lymphomas, and stomach, intestinal, and ovarian cancers. (70 refs)

151. CARCINOGENS IN DRINKING WATER.

Miller RW
NCI, NIH, Bethesda, MD 20014
Pediatrics; 57(4):462-464 1976

Asbestos, the carcinogenic qualities of which when inhaled are considered the result of its physical properties, has been found in high concentrations in drinking water. On the other hand, animal studies have indicated that when asbestos is ingested, it is not carcinogenic. Human occupational exposure to asbestos, however, is associated with increased frequencies of gastrointestinal cancer, presumably from the swallowing of the compound. The high cancer mortality of whites in New Orleans is reported to be due to the presence of carcinogens in the water, despite the facts that the high cancer incidence is primarily in the lungs, women are less affected than men, and different communities with the same water supply show different effects. Vinylchlorides, pesticides, and polycyclic hydrocarbons are considered the most harmful. Chlorination leads to the formation of four carcinogens (chloroform, bromoform, bromodichloromethane, and dichloromethane). Chloroform is considered potentially the most dangerous, although no human correlations have been found. The fetus and child may be more susceptible than adults to these carcinogens. No basis for recommending changes in water supply exists.

152. FACT AND FANCY ABOUT DRINKING WATER.

Stewart WH
Louisiana Health and Human Resources Admin., LA
Am J Public Health; 65(10):1111 1975

The finding of minute quantities of carcinogenic substances in water supplies necessitates epidemiological studies to determine cause and effect relationships between these substances and cancer mortality in the exposed population. The release of results to the public before they are evaluated may result in expensive measures being taken that are later found to be unnecessary. The burden of proof becomes shifted from the researcher to the public health officials to show that the drinking water is safe. This defensive posture is a result of our increasing ability to detect foreign substances in the environment, which has outstripped our ability to understand the biological consequences of these substances. Scientific criticism is needed to separate fact from fancy in debates regarding such issues of public health.

153. ORGANIC POLLUTANT CONCENTRATIONS IN SURFACE WATERS AND AT DIFFERENT STAGES OF DRINKING-WATER PREPARATION.

Schalekamp M, Dietlicher K, Valenta J, Wattenhofer R, Zimmermann U
Service des Eaux de Zurich, Case postale 3345, 8023 Zurich, Switzerland
Gaz Wasser Abruases; 58(11):633-643 1978

The general problems of organic substances in raw and drinking water are reviewed. Specific organic pollutants are discussed and the carcinogenic and toxic effects of these substances and their effect on water taste are discussed. A correlation has been reported between the haloform concentration in chlorinated drinking-water and the high rate of gastrointestinal cancer mortality in Louisiana. Chloroform was found to be carcinogenic. (41 Refs)

154. RADIOACTIVE CONTAMINATION OF THE ENVIRONMENT AND THE POSSIBLE CONSEQUENCES.

Knizhikov VA, Barkhudarov RM
Biophysics Inst. of the U.S.S.R. Ministry of Health, Moscow, U.S.S.R.
At Energy Rev; 13(2):171-214 1975

The main sources, pathways, doses, and consequences of radioactive environmental contamination are reviewed. The global nature of effects on the biosphere is discussed, and the source of radioactive contamination are discerned. There major sources are radioactive fall-out following nuclear explosions, nuclear power stations and industries, and diagnostic radiology and radiotherapy. These are discussed in relation to nuclear weapons tests, nuclear explosions for peaceful purposes, nuclear-powered transport, and the problems of burial and safe handling of radioactive waste.

Current levels of radioactive contamination of the biosphere are evaluated; the radiobiological significance is determined by: (1) the yield from fission or fusion of nuclear fuel, (2) the rate and level of uptake in food, (3) the rate of absorption from the gastrointestinal tract, (4) the extent of deposition in the critical organ, and (5) the type and energy of the radiation. The strontium-90 and cesium-137 content of soil and water has been evaluated, and the migration of the radioisotopes through biological chains has been investigated; particular attention has been given to isotopes in foodstuffs and in drinking water. While peaceful nuclear explosions and nuclear power stations constitute contaminations pathways not connected with global fall-out, the major environmental contamination results from stratospheric fall-out. The effect of age and dietary habits on the accumulation of radioisotopes in the body is discussed. A consideration of the population doses from external and internal irradiation notes the various organ depositions of the isotopes, doses from the natural radiation background, and the medical therapeutic and diagnostic applications. The concepts of acceptable risk, somatic effects, genetic effects, and ecological aspects are discussed in relation to the possible consequences of radioisotopes contamination of the biosphere. (185 refs)

155. ENVIRONMENTAL MUTAGENS AND CARCINOGENS.

Nagao M, Sugimura T, Matsushima T
Natl. Cancer Center Res. Inst., Chuo-ku, Tokyo 104, Japan
Annu Rev Genet; 12(1):117-159 1978

Various types of environmental mutagens are reviewed, and other factors related to the detection and study of these substances are discussed. Mutation tests using microbes, an in vitro transformation test using cultured mammalian cells, other short-term test systems for the detection of environmental mutagens and carcinogens, and in vivo long-term animal tests for environmental carcinogens are described. Naturally occurring agents include those produced by fungi and plants and fatty acid peroxides in foods. Among those produced by fungi, aflatoxin B1 is the strongest mutagen and carcinogen. Proven or possible mutagens and/or carcinogens produced by other plants include cycasin, substance(s) in bracken fern, pyrrolizidine alkaloids, flavonoids, quercetin, hydrazine, safrole, isosafrole, dihydrosafrole, monocratalin, and heliotrine. The fatty acid peroxide, malonaldehyde, has been found to be mutagenic to Salmonella typhimurium TA1978. Another source of environmental mutagens is pyrolysis products, which include cooking products, tobacco tar, and aromatic hydrocarbons. Other sources discussed include nitrosation products, synthetic chemicals (food additives, cosmetics, drugs, pesticides, household materials, and occupational substances and industrial intermediates), and water pollutants and air pollutants. In addition, factors modifying mutagenesis and carcinogenesis, evaluation and quantitation of data, and overlapping of mutagens and carcinogens are discussed. (311 Refs)

156. CIRCULATION OF CARCINOGENIC SUBSTANCES IN THE ENVIRONMENT: FROM LABORATORY EXPERIMENTS TO FIELD INVESTIGATIONS.

Shabad LM
Dept. Carcinogenic Agents, Inst. Experimental and Clinical Oncology, Novopeecheneja-str., 3 ap., 64 Moscow 125057, USSR
Gann Monogr Cancer Res; 17:179-187 1975

The relationship of environmental chemicals to the increased incidence of cancer in the last few decades is discussed. An enormous increase in the incidence of lung cancer during the last 50 yr in industrialized countries has led to investigations of air pollution. Levels of polycyclic aromatic hydrocarbons (PAH), including the highly carcinogenic compound benzo(a)pyrene (BP), in the air, soil, water and sea food have been evaluated. Main sources of PAH in the air include heating systems, industrial plants, and internal combustion engines. The amount of BP accumulated in the soil has been shown to decrease over a period of time as it passes into plant life or is destroyed mainly by soil microorganisms, such as B sphericus. BP can also be destroyed by UV rays in the upper soil layers or pass into groundwater from the lower levels. The most serious sources of carcinogenic water pollution include industrial sewage, internal combustion engines of ships and boats, and sewage from cities. In general, more pollution has been found in industrial areas in the USSR. A general scheme for circulation of PAH in the environment is described. In bodies of water, BP can accumulate in bottom sediments or in aquatic plants and eventually enter living organisms used as human food. Evidence shows a promising natural phenomenon of BP metabolism and degradation in humans as well as other organisms. Since the quantity of a carcinogen seems to be an important factor, recommendations for establishing tolerance levels are discussed. (31 refs)

157. ENVIRONMENTAL POLLUTION AND CARCINOGENIC RISKS.

World Health Organization International Agency for Research on Cancer and Institut National de la Sante et la Recherche Medicale
Proceedings of a Symposium Held by the International Agency for Research on Cancer and the French National Institute of Health and Medical Research, 3-5 November 1975. Paris France, INSERM Symposium Series vol. 52, IARC, no. 13, 476 pp, 1976. 1.9002

This publication reproduces the 34 papers presented at the Symposium on Environmental Pollution and Carcinogenic Risks, held in Lyon, November 3-5, 1975 and organized jointly by the International Agency for Research on Cancer (IARC) and the French National Institute of Health and Medical Research. The papers are classified according to the following topics: atmospheric pollution (5 papers), water pollution (2), occupational pollution (7), radiation pollution (2), identification of carcinogens (6), assessment of carcinogenic risk (2), measurement of potential carcinogens in the environment (4), and industrial and legal aspects of occupational carcinogens (5). A list of references is included with each paper. Appendices give the names and addresses of Symposium participants and titles of INSERM and IARC publications. (refs)

158. THE IMPORTANCE OF TOXIC SUBSTANCES IN DRINKING WATER.

Koch R
Am Eichwald 4, DDR-65 Gera, E. Germany
Z Gesamte Hyg; 23(2):96-98 1977

Problems resulting from the increased pollution of water with organic and inorganic substances that are detrimental to human health are reviewed. Water polluting toxic substances include carcinogenic aromatic hydrocarbons, aromatic amines, nitrogen-nitroso compounds, pesticides, polychlorinated biphenyls, hormones, antibiotics, aromatic and aliphatic halogenic hydrocarbons, mercuric compounds, and cadmium, lead, vanadium, zinc, arsenic, chromium, nitrate, and nitrite. Approximately 300 synthetic chemical compounds enter environmental waters each year. Since water is a good transport system and essential in human nutrition, a differentiation of suspected toxic effects and actual toxic effects of these pollutants to humans is of primary concern. Statistical epidemiological analysis and long-term animal experiments help to determine the minimum concentrations of these pollutants that may be hazardous to human health. Numerous potentially toxic substances which occur in various

concentrations in drinking water are biologically reactive but chemically and physically stable and may thus accumulate in various parts of the body (liver, kidneys, brain). Certain partially toxic substances undergo metabolism through detoxification reactions in the body (parathion to paraoxan and malathion to malaoxan) and may thus become toxic. A combination of toxic substances, even in minute concentrations, may lead to a synergistic effect in the body. In the presence of chloro-organic compounds there is a decrease in resistance to viral infections in some organisms. The establishment of minimum and maximum pollutant levels for drinking water as well as new filtering methods for water sanitation are of the utmost importance. (no Refs)

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